A SKETCH

OF THE

GEOGRAPHY AND GEOLOGY

OF THE

HIMALAYA MOUNTAINS AND TIBET

BY

COLONEL S. G. BURRARD, R.E., F.R.S.,
SUPERINTENDENT, TRIGONOMETRICAL SURVEYS,

AND

H. H. HAYDEN, B.A., F.G.S.,
SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA

PART III

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PREFACE

IN 1807 a Survey detachment was deputed by the Surveyor General of Bengal to explore the source of the Ganges: this was the first expedition to the Himalaya undertaken for purely geographical purposes. A hundred years have now elapsed, during which geographical and geological information has been steadily accumulating, and we have at length reached a stage where there is danger of losing our way in a maze of unclassified detail: it is therefore desirable to review our present position, to co-ordinate our varied observations and to see how far we have progressed and what directions appear favourable for future lines of advance.

The present paper originated in a proposal submitted by the Survey of India to the Board of Scientific Advice at the meeting of the latter in May 1906. The proposal was as follows:—"The number of travellers in the Himalaya and Tibet is "increasing, and a wider interest is being evinced by the public in the geography of "these regions. It is therefore proposed to compile a paper summarising the geographi-"cal position at the present time."

Subject to the modification that the scope of the paper should be geological as well as geographical, this proposal has received the sanction of the Government of India and the work has been entrusted to us to carry out. On the understanding that the paper is intended primarily for the use of the public, we have endeavoured to avoid purely technical details and to present our results in a popular manner.

Our subject has fallen naturally into four parts, as follows:—

PART I.—The high peaks of Asia.

PART II.—The principal mountain ranges of Asia.

PART III.—The rivers of the Himalaya and Tibet.

PART IV.—The geology of the Himalaya.

Though the four parts are essentially interdependent, each has been made as far as possible complete in itself and will be published separately. The first three parts are mainly geographical, the fourth part is wholly geological: the parts are subdivided into sections, and against each section in the table of contents is given the name of the author responsible for it.

PREFACE

The endeavour to render each part complete must be our apology for having repeated ourselves in more places than one: the relations, for instance, of a range to a river have been discussed in Part II, when the range was being described, and have been mentioned again in Part III under the account of the river.

As the mountains of Asia become more accurately surveyed, errors will doubtless be found in what we have written and drawn: it is not possible yet to arrive at correct generalisations and we have to be content with first approximations to truth.

Maps, too large for insertion in such a volume as this, are required for a study of the Himalayan mountains: the titles of maps illustrating the text are given in foot-notes and are procurable from the Map Issue Office of the Survey of India in Calcutta. Constable's hand-atlas of India will be found useful.

We are much indebted to Babus Shiv Nath Saha and Ishan Chandra Dev, B.A., for the care with which they have checked our figures and names, and to Mr. J. H. Nichol for the trouble he has taken to ensure the correctness of the charts. Mr. Eccles and Major Lenox Conyngham have been kind enough to examine all proofs, and to give us the benefit of their advice and suggestions. Mr. Eccles has also supervised the drawing and printing of the charts, and we have profited greatly by the interest he has shown in them.

S. G. BURRARD.

H. H. HAYDEN.

March 1907.

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Charts IX to XXII are included in Part II.

THE RIVERS OF THE HIMALAYA AND TIBET.

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THE DRAINAGE OF THE PLATEAUX.

THE high plateaux and mountains which we have been describing in Part II contain the sources of the principal rivers of Asia. In chart XXIII the drainage is illustrated.

If we commence at the Tian Shan and work round by west to south, and thence to east, we find that the rain and snow, which fall on the plateaux, flow to the lower levels of Asia in the following ways :—

(i) The northern slopes of the Tian Shan are drained by small rivers that flow on the east into the Mongolian lakes and on the west into lake Balkash.

(ii) The western portions of the Tian Shan are drained by the Jaxartes (Syr Darya) and the western flank of the Pamir plateau by the Oxus (Amu Darya). The Jaxartes and the Oxus empty their waters into a flat shallow depression of western Asia, and create the sea of Aral.

(iii) The Helmand, draining the western portions of the Hindu Kush, has its course stopped by a small range of hills on the borders of Afghanistan and Persia, and, being forced to empty itself into a flat inland desert basin, it creates the lagoon of Seistan.*

(iv) Feeders of the Indus, described in detail hereafter, drain the southern slopes of the Hindu Kush and Karakoram ranges, and both the northern and southern slopes of the Punjab Himalaya.

(v) Feeders of the Ganges and Brahmaputra carry off all the water and snow that fall on the Kumaun, the Nepal and the Assam Himalaya.

(vi) The Irrawaddy, the Salween and the Mekong drain the south-eastern portions of Tibet, and flow, the two first into the Bay of Bengal, and the last into the Pacific Ocean.

(vii) The Yangtze and Hoang Ho drain Eastern Tibet, and flow through China to the Pacific Ocean.

(viii) The rivers of the Tarim system drain the interior of the horse-shoe, and empty their waters into the shallow lagoons of Lob Nor.

(ix) The rivers of Central Tibet flow into one or other of the numerous Tibetan lakes, and have no outlet to the sea.

In comparing rivers we can have regard to the areas of their basins, or to the volumes of their discharges, or to the populations they support; and the following table, though not based altogether upon trustworthy data, will give some idea of the order of

* Vide *Journal, R. G. S.*, Vol. 43, 1873, page 278 : also Holdich's geographical notes, Afghan Boundary Commission, *Proceedings, R. G. S.*, Vol. VII, 1885 : also *Annual Report of the Board of Scientific Advice for India*, 1905-06.

importance of the different drainage systems.* In this table the most important system is that numbered "1" and the least important is that numbered "13."

TABLE XXIX.

Drainage system.	Order of importance of the several rivers, as estimated:		
	from size of basin.	from discharge of water.	from population supported.
Yangtze	1	1	1
Hoang Ho	2	2	2
Ganges	3	3	3
Mekong	7	5	4
Indus	6	7	5
Brahmaputra	8	6	6
Irrawaddy	9	4	7
Tarim	4	10	9
Oxus	10	8	8
Rivers flowing into Tibet lakes	5	11	13
Salween	11	9	12
Helmand	12	12	11
Jaxartes	13	13	10

The primary water-partings.

Chart XXXV has been drawn to illustrate the primary water-partings of the high plateaux. The highest ranges of mountains† are shown by dotted lines with heavier dots at intervals to symbolise peaks, and the main water-partings are shown by black continuous lines. In places where the highest range forms the main water-parting a dotted line and a continuous line have been drawn side by side. The water-parting between India and Tibet has been shown by a double line.

The Tarim basin.

In order to study this chart we will commence with the Tarim basin.‡ The Tarim basin lies between the Tibet plateau and the Tian Shan. Its surface is a sandy desert, and the Tarim river, which drains the Karakoram, the Kuen Lun, the Tian Shan and the Pamirs, is the only source of life. "This great depression," writes Prince Kropotkin, "is only relative in comparison "with the high plateaux which surround it, and represents on the contrary a vast mas-"sive swelling of the Earth's crust. In its western portion it has still an altitude of "from 3000 to 4000 feet, and 2600 feet in its lower part,—the depression of the Lob Nor."§ On the east the ranges of the Tian Shan approach those of north-east Tibet, and the mouth of the Tarim basin becomes narrow, but the two systems of mountains do not actually come into contact at this point, and the plains of Tarim are continued without interruption into Mongolia and the deserts of Gobi. The surface of the desert inside the basin is at a lower level than that of Gobi outside.

* Rivers draining the northern slopes of the Tian Shan are omitted from the table.

† Compare chart XXXV with frontispiece to Part I and with chart XXIII.

‡ Map of Turkistan, 1 inch = 32 miles.

§ *Geographical Journal*, Vol. XXIII, 1904. *The Orography of Asia.*

The rivers of Tarim empty their waters into the lagoons of Lob Nor (see frontispiece to Part I). Sven Hedin has shown that whilst these lagoons are getting choked with sand, the desert on their north is being excavated by wind: their water, he says, will ultimately overflow and seek the lower level. This has happened before, and in 265 A.D. Lob Nor lay considerably north of its present position. As the lakes move, so do the vegetation, the animals, and the fisher-folk; and Sven Hedin calls Lob Nor the oscillating pendulum of the Tarim river.*

The rivers of the Tarim basin may be divided into four classes:—

(i) There are the rivers rising in the Tian Shan mountains. The water-parting of the Tian Shan dividing the drainage of the Jaxartes from that of the Tarim is north of the principal range in one place only.† At the peak of Tengri Khan (*vide* table VI), near the meridian of 80°, the Tian Shan range appears to bend to the south-west, and to throw off a northern branch. The river Sariati drains the basin enclosed between the branches, and breaking through the southern and principal range it flows into the Tarim basin. The area drained by the Sariati north of the Tian Shan main range is marked A on chart XXXV.

(ii) There are the rivers that drain the trough between the Sarikol and Kashgar ranges; these have carved passages through the latter and flow eastward into the Tarim basin. The areas drained by these rivers behind the main Kashgar range are marked D on chart XXXV.

These rivers are:—(*a*) The Ulu-Art (or Yanymya or Muji) which drains the whole trough north of Muztagh Ata, and which pierces the main range by the Gaz defile. (*b*) The Tashkurgan river, which, rising north of the Kilik pass on the Indus-Tarim water-parting, drains the trough south of Muztagh Ata, and passes eastwards through the Kashgar range by the Chiragh Tar gorge 60 miles south of the Gaz defile.‡

Many rivers rise on the eastern slopes of the Kashgar range and flow into the sandy deserts of Tarim.

(iii) The Yarkand river, which drains the area marked E on chart XXXV.

The Yarkand river is the largest and the most important of all the rivers of Tarim;§ it collects the drainage of two parallel troughs, the Karakoram-Aghil trough, 100 miles long, drained by the Oprang tributary, and the Aghil-Kuen Lun trough, 170 miles long, drained by the Raskam; it pierces both the Aghil and Kuen Lun ranges, and it carries water from the glaciers of peak K^2 to the lagoons of Lob Nor.

South-east of K^2 the Indus-Tarim water-parting leaves the main Karakoram range and bends sharply to the north-east: feeders of the Yarkand river

* *Geographical Journal*, Vol. XXI, 1903. *Three years' Exploration in Central Asia.*

† Not knowing how reliable the maps of Tian Shan may be, we can only refer to topographical features with diffidence.

‡ The Chiragh Tar gorge was explored by Rai Sahib Ram Singh in 1906.

§ In its mountain course it is known as the Raskam Darya and the Zarafshan river.

receive the drainage of the re-entering angle thus formed, as far east as the meridian of 78°.

(iv) The Karakash river drains the area marked F on chart XXXV, and the Kiria river drains the area marked J. The Karakash river flows for 100 miles in a trough south of the Kuen Lun, before it pierces the range at Shahdulla.

The northern slopes of the Kuen Lun, between the areas F and J of the water-parting chart, are drained by the Yurangkash river: the Karakash and Yurangkash are within fifteen miles of one another when passing the town of Khotan, but they do not unite for another 80 miles.

After their junction they are called the Khotan river.

A vast number of minor rivers drain the northern slopes of the Kuen Lun and lose themselves in the sands of the desert.*

The Yarkand river contains water all the year round, but the Khotan river remains dry during the greater part of the year. "The Khotan river," writes Sven Hedin, "flows through the worst section of the Takla Makan "desert, and has a far harder fight of it with the drift sand than its "sister stream to the west (Yarkand). Indeed the sand is seriously "threatening to choke it up and cut it off from the main river—a fate "which has already overtaken the Kiria Darya."† Sven Hedin reached the point where the Kiria river died away in the sand, "finally giving "up its desperate struggle against the desert."

The water-parting between the Tarim basin and the Tibet lake-basin was taken for chart XXXV from old maps and is shown too far north in longitude 84°. According to modern maps the water-parting in this longitude is hardly north of latitude 36°, and chart XXIII is probably more nearly correct. In the frontispiece chart of Part I the axis of the Kuen Lun was shown too far north in longitude 84°.

Chart XXXV shows that the Jaxartes drains the western portions of the Tian Shan, and that the Oxus drains the Pamir plateau: the Sarikol range forms the water-parting between the Oxus and the Tarim.

The Jaxartes and the Oxus.

The Hindu Kush consists of two parallel ranges of which the southern is a westerly extension of the Karakoram fold, and carries the highest peaks. The northern however forms the water-parting between the Oxus and the Indus, except for a length of 50 miles south-west of Tirich Mir, where the southern Hindu Kush range is the divide.‡ Further to the west the southern range becomes for a similar length the water-parting between the Oxus and the Helmand.

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* Royal Geographical Society's map published in Holdich's *Tibet the Mysterious*.

† Sven Hedin: *Through Asia*, 1898.

‡ North-West Trans-frontier Sheet No. 26, 1 inch = 8 miles.

The Indus.

The two Hindu Kush ranges will be seen from chart xxxv to enclose a long narrow trough, and the drainage of this trough flows alternately north and south.* On the west the trough forms the narrow basin of the Hari Rud river, flowing westwards into the desert. East of the Hari Rud basin comes a portion of the trough that is drained by streams flowing northwards : then follows the long area marked B on the chart, which is drained by the Panjshir tributary of the Kabul river, and which belongs to the basin of the Indus.

Thus in the first instance the two Hindu Kush ranges form water-partings enclosing a single river : then the southern range becomes the water-parting, and subsequently throughout area B the northern range. Near the meridian of 71° occurs another change, the southern range becoming the water-parting again and the trough draining northwards into the Oxus. A few miles west of Tirich Mir appears a third change, the Arkari river rising in the northern range and flowing into the Indus. Eastwards from Tirich Mir the northern Hindu Kush range remains the water-parting, and the trough between the ranges is drained by affluents of the Indus.†

The Kilik pass is very near the point of trijunction of the basins of the Tarim, the Oxus and the Indus:‡ from this locality rivers take three different directions; the Panj branch of the Oxus flows towards the west, the Tashkurgan tributary of the Tarim flows east, and the Hindu Kush feeders of the Indus flow south.

The long area marked C on chart xxxv stretching east from Tirich Mir is drained by the Kunar, Gilgit and Hunza rivers, which force separate passages through the Karakoram range :§ the two latter unite near Gilgit and eventually join the Indus at its knee-bend above Bunji. The range which forms the water-parting in rear of the area C is lower than the main range to the south.

The area marked H is drained by the Shyok tributary of the Indus : the water-parting north-east of H will be seen to be in the same alignment as the water-parting north-east of C, and it has been surmised that the two are perhaps different portions of one range ; if this proves to be the case it will furnish another example of how a water-parting alternates between one and the other of two parallel ranges, clinging to the north-eastern range behind areas C and H, and to the Karakoram in the interval.

The water-parting in Tibet between the Karakash tributary of the Tarim (area F) and the Shyok tributary of the Indus (area H) is however not in all places a mountain range, as the following extracts from a letter from Mr. Shaw to Sir Roderick Murchison will show :—‖ "What was my astonishment after walking a few yards to find some water "trickling westwards towards the mountains. I had, therefore, already passed the "imperceptible watershed between the great river systems of the Indus and of Central "Asia. Beyond the lake we had just passed, the waters feed the Karakash ; while the

* The longitudinal section in chart xx shows the portion of the southern Hindu Kush range that forms the water-parting between Indus and Oxus.

† Map of Afghanistan, 1 inch = 16 miles.

‡ Northern Trans-frontier Sheet No. 2, 1 inch = 8 miles.

§ See longitudinal section in chart xx.

‖ *Proceedings, Royal Geographical Society*, Vol. XV, 1870-71.

"trickling stream which I had reached pierces the great limestone range and much "augmented on the way runs through the rocky gorges into the Shyok, which is one "of the chief sources of the Indus."

"Thus the great water systems of southern and of Central Asia are here separated "by no gigantic mountain range, but merely by a few yards of level sand, at a prodigious "elevation it is true."

Between the area H and the Aling Kangri the Kailas range is believed to be the Indus-Tibet water-parting.

The great Himalayan range runs north-westward from the Badrinath-Gangotri peaks to Nanga Parbat, and west of the meridian of 78° both its faces are drained by feeders of the Indus: it may be argued then, that this range south-east of Nanga Parbat should not have been shown on chart XXXV as a primary water-parting, the whole region being in the basin of the Indus. But we have not accepted this view; we are treating in this paper of the Himalaya and Tibet, and not of the hydrography of Asia: the Punjab Himalaya form a water-parting between great Himalayan rivers,—the Indus on one side and the Jhelum and Chenab on the other; and the fact that the Jhelum and Chenab subsequently join the Indus in the south-west of the Punjab does not affect the question. The coincidence of the Indus-Chenab, and of the Indus-Jhelum water-partings with the crest-line of the Punjab Himalaya presents a most interesting contrast to the divergence that obtains in the Kumaun, Nepal, and Assam Himalaya.

The rainfall on the Indian side of the Punjab Himalaya is greater than on the Tibetan side, and the slopes on the Indian side are steeper than on the Tibetan. The tributaries then of the Chenab and Jhelum, descending from the crest-line, should have greater volumes and velocities, and should be able to deepen their channels and expand their basins more rapidly than the feeders of the Indus on the opposite side of the crest, and the water-parting should now be slowly retiring towards the Indus. But if this process had been actually in operation, the water-parting would be a more sinuous line than it is.

There are but two sinuosities in the crest-line of the Punjab Himalaya. The first is in the shape of an S, of which the Nun Kun peaks form the central point: on the south of the Nun Kun the water-parting is being shifted towards Tibet, but on the north it appears to be moving towards India. The second sinuosity has been caused by the Rupal glacier cutting back from the north immediately south of Nanga Parbat, and in this instance the water-parting is being shifted towards India and not towards Tibet. The Punjab Himalaya thus furnish an interesting example of a range, on which the water-parting seems in places to be moving towards the side of greater rainfall and steeper slopes.

The Sutlej.

The area marked L is drained by feeders of the Sutlej; and that marked K by the Spiti tributary of the Sutlej. The area marked Z denotes the Manasarowar basin.*

* Northern Frontier Sheet No. 14 S. W., 1 inch=4 miles.

As will be described hereafter, the Manasarowar lakes overflow at times into the Sutlej and on chart XXXI the lake-basin has been included in the area drained by the Sutlej. If the Manasarowar lakes had been held to belong to the Tibet lake-basin, the double line of chart XXXV would have been made to encircle them.

The drainage system that obtains between Manasarowar and the great Himalayan range is complex. The Ganges and the Kali drain the northern slopes of the great range in Kumaun, the Zaskar range forming the limit of their basins in Tibet. The water-parting between the areas Z and M is, however, not the Zaskar but the Ladak range. The area L is drained by the Sutlej flowing north-west, and the area M by the Karnali flowing south-east, the Sutlej and Karnali basins being in contact across the Tibetan plains. The Zaskar range separates the basins of the Sutlej and Karnali on the one side from those of the Ganges and the Kali on the other. The Sutlej and Karnali drain the trough between the Zaskar and Ladak ranges, and the Ganges and Kali drain that between the Zaskar and the Great Himalayan ranges. The Ganges and Kali rise behind the Great Himalayan range but not behind the Zaskar; the Sutlej and the Karnali rise behind the Zaskar range, and their basins touch behind the basins of the Ganges and the Kali.*

The Ganges of Bengal.†

The areas M, N, P and R are all drained by tributaries of the Ganges of Bengal which rise in the Ladak range behind the great Himalaya and pierce the latter. East of Nampa there is no range like the Zaskar intervening between the great Himalayan and Ladak ranges, and the drainage is less difficult to unravel. The parallelism here of the water-parting and the great Himalayan range is very marked; it seems to indicate that the water-parting is following an original axis of elevation.

The Brahmaputra.

Near Chumalhari the great range becomes, for a short length only, the water-parting between India and the Brahmaputra in Tibet.‡ In the Assam Himalaya the area S behind the great Himalayan range is drained by the Assam rivers Raidak and Manas. The Ladak range forms the water-parting between the Ganges of Bengal and the Brahmaputra throughout the areas N, P, R and S, all of which are drained by rivers which pierce the Great Himalayan range and flow *southwards*: but near Chumalhari occurs the solitary exception; here the Nyang river pierces the Ladak range and flows *northwards* into the Brahmaputra.§

The water-parting between the Indian and Tibet basins cannot be drawn with certainty: in places it is without doubt the Kailas range, but the latter has been cut through from the north by feeders of the Brahmaputra whose basins have not been determined. The Lhasa river, the Charta and others drain the trough north of the Kailas range, and pierce the Kailas range in the same way as the Himalayan rivers pierce the Himalayan

* The basins of these rivers are described in detail hereafter.

† We must endeavour to avoid confusion from a double use of the name Ganges: we have in chart XXIV applied the name Ganges to the Himalayan basin drained by the river above Hardwar: but in Part III we have employed the name Ganges to include the whole basin drained by the Ganges of Bengal and its tributaries. Both applications are correct, and the context must be trusted to indicate the meaning in each case.

‡ North of Chumalhari is a small lake-basin containing the Kala Tso. See Ryder's note on overflows from this basin in his *Report on Survey operations with the Tibet Frontier commission*, 1904.

§ North-Eastern Frontier sheet No. 7 N. W., 1 inch=4 miles. North-Eastern Frontier sheets Nos. 6 N. W., 6 S. W., 6 N. E., 6 S.-E., 1 inch=4 miles.

ranges. Their waters flow into India and their basins belong not to Tibet but to the Brahmaputra.

From the basin of Tibet (charts XXIII and XXXV) no water escapes to the sea. In the interior of the plateau the troughs contain long series of lakes. Several rivers of considerable volume are known to rise in Tibet, and to empty their waters into one or other of its lakes.

The closed basin of Tibet.

The rainfall over the basin was doubtless greater in former ages than at present: the rise of the great Himalayan range during recent geological periods must have cut off much of the rain that would have formerly reached Tibet. The clouds laden with moisture from the Indian Ocean now drop the greater portion of their burden on the outer Himalayan ranges: each successive range receives less rain than the one immediately exterior to it. Central and western Tibet are consequently sterile regions; eastern Tibet, however, is watered by rain-bearing winds from the Pacific Ocean.

In drawing chart XXIII we were in doubt whether the inland basins of Tsaidam and Koko Nor should be included as part of the closed basin of Tibet or not. We have excluded them, and on this chart they form part of the area allotted to the Mongolian lakes.

If the Tibet lake-basin is held to include the whole elevated area from which no water escapes to the sea, then Tsaidam and Koko Nor perhaps belong to it: Tsaidam is, however, 6000 feet and Koko Nor 4400 feet lower than Tibet.

The closed basin of Tsaidam is in contact with the closed basin of Tibet on one side, and with the closed basin of Koko Nor on the other, and the three form one continuous area encircling the upper Yangtze and Hoang Ho. But continuity of area does not justify the assumption that the three enclosed basins are parts of one geographical whole, for the inland basins of Tarim and Mongolia, neither of which possesses any outlet for drainage, are also in contact with Tsaidam and Koko Nor.

The Kuen Lun range separates Tsaidam from Tibet, and we have taken this range to be the north-eastern boundary of the Tibet lake-basin: the basins of the Yangtze and Hoang Ho separate Koko Nor from Tibet.

The Tibet lake-basin, it will thus be seen, does not coincide with the Tibet plateau: the plateau includes besides the lake-basin the upper valleys of the Indus, Yangtze, Hoang Ho, Salween and Brahmaputra and the outlying plains of Tsaidam and Koko Nor: the lake-basin consists only of the compact portion of the Tibet interior that has no outlet for drainage.*

The peculiar feature of the Irrawaddy (chart XXIII) is its immense volume of water in northern Burma: Mr. Gordon estimated the high flood discharge of this river above Bhamo as 1000000 cubic feet per second: its width at Bhamo is six miles.

The Irrawaddy.

* An idea of the shape and size of the Tibet plateau can be obtained, if we recollect the longitudes of three of its principal lakes. Pangong, the extreme western lake of the plateau, is in longitude 80°: Nam Tso (Tengri Nor) at the south-eastern corner of the Tibet basin is in longitude 90°: Koko Nor at the extreme north-eastern corner of the *plateau* is in longitude 100°.

The catchment basin above Bhamo has according to modern maps an area of 18000 square miles, and is smaller than the Himalayan basins of the Kosi, the Karnali or the Sutlej. Its immense discharge, issuing as it appears to do, from the drainage of a small area led Mr. Gordon to believe, that the old Chinese surveyors had been right, and that the Sangpo of Tibet flowed into the Irrawaddy.

During the latter half of the nineteenth century, however, geographical evidence continued to accumulate, and the identity of the Sangpo of Tibet with the Brahmaputra of India has now been proved.

General Walker has endeavoured to account for the great volume of the Irrawaddy by assuming that the Lu river of Tibet flows into it. The Lu had always been supposed to be the upper course of the Salween, and General Walker was led to adopt his view by the account of the explorer Kishen Singh, who described the Salween south of latitude 30° as an *insignificant stream.* But the casual observations of explorers are unsafe data, and General Walker's view has not been accepted by geographers.

What Kishen Singh did prove was that no Tibetan river *west* of the Lu was flowing into the Irrawaddy. In 1895 Prince Henry of Orleans marched across from Southern China into Assam : he crossed the Mekong and the Salween, but not the Irrawaddy : he stated that the most northern branch of the Irrawaddy rises in a latitude not higher than 28° 30′.*

The three rivers of south-eastern Tibet.

The parallelism and proximity of the Yangtze, the Mekong and the Salween in their exits from Tibet are amongst the most extraordinary features of the earth's land surface : each of these rivers drains a large area of eastern Tibet (chart XXIII), and on the surface of the plateau they flow at considerable distances from one another. But during their descent they bend to the east-south-east, and assume absolutely parallel courses, the Mekong in the centre being 28 miles from the Yangtze and 20 miles from the Salween. Here then are three trunk rivers, each larger than the Sutlej, flowing through a mountain zone 48 miles wide.

In 1880 Kishen Singh crossed the three parallel rivers near latitude 30°: of the Yangtze he wrote :— "At 10 A.M. we crossed the Di Chu, here about 300 paces "wide and having a rapid current."

Of the Mekong he wrote :—"The arrangement for crossing consists of a thick "leather rope stretched very tight from an elevated point on one bank to a lower "level on the opposite bank. The length of the rope-bridge was estimated to be "about 130 paces."

Of the Salween he wrote :—"We crossed the river Giama Nu Chu, also called "Nu Chu, which is deep and rapid and about 200 paces wide."

The Salween.

Since Mr. Hennessey published his account of Kishen Singh's explorations, the Tibetan course of the Salween has been shown on maps as the Giama Nu Chu. No reliable observer has as yet traced the course of the Salween from its source in Tibet to the point where it appears

* *Geographical Journal*, Vol. VII, 1896.

in Burma. At its exit from Tibet it is shown on maps to be confined between two mountain ranges, and as possessing no affluent for 200 miles. If geographers are justified in doubting still the identity of the Sangpo of Tibet with the Brahmaputra, when 40 miles of its course alone remain unexplored, how much greater uncertainty must they feel over the identity of the Lu river of Tibet with the Salween of Burma, when the unexplored link exceeds 200 miles.

The geography of the Salween has been rendered obscure by the multitude of names which have been applied to its supposed upper courses. "It is mentioned," writes Mr. Gordon, "in the Yuking of China 2200 B.C., as the Black River issuing from "the Black Lake of Tibet, where it has already had a long course from the Northern "Himalaya through the high plains of the great lake region, as the Targot or Shyal "river, and it successively takes the names of Nag Chu Kha, of Lu Chu and of Nu Chu "and finally emerges from the plateau in about latitude 26° as the Salween."*

In his report on the trans-Himalayan explorations of 1873-74-75 Colonel Trotter expressed doubts as to whether the Nag Chu Kha of Tibet, which Mr. Gordon assumes to be a feeder of the Salween, was not a branch of the Yangtze or the Mekong.

In the map published by the Royal Geographical Society in 1894, the river which rises in Tibet north-east of lake Tengri Nor was made in accordance with General Walker's views the upper course of the Irrawaddy. The exploration of Prince Henry of Orleans led to the basin of the Salween being largely expanded in maps of Tibet and that of the Irrawaddy being greatly reduced.

The Mekong.

The Neg Chu Kha of Tibet, which is now, and perhaps prematurely, identified on maps with the Salween, was crossed by Fathers Huc and Gabet, who were told that it was the Mekong. According to Dutreil de Rhins, who believed that he had traced the Mekong to its source, its Tibet name is the Chiamdo Chu. Other names are however applied to the Mekong, notably the Da Chu and the Nam Chu.

Whilst we owe much to the intrepid explorers who have penetrated eastern Tibet, our geographical knowledge of this region is still very imperfect. We have not yet ascertained the true positions of the sources of the Salween and the Mekong (chart XXIII), and future surveys will probably discover great errors in existing maps. The problem has been complicated by the convergence of the Salween, the Mekong and the Yangtze as they issue from Tibet: when the courses of three great rivers lie within 50 miles of one another, it is hardly possible for an explorer to decide to which of the three a very distant feeder belongs, unless he follows the stream down: hitherto explorers have only crossed the rivers at right angles, and none have yet succeeded in following their courses.

Mr. Gordon estimated the discharges of the Salween, Mekong and Irrawaddy in the same latitude to be in the proportions of one, three and nine.†

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* *Proceedings, Royal Geographical Society*, Vol. VII, 1885.

† *Proceedings, Royal Geographical Society*, Vol. IV, 1882.

The Yangtze is the largest river of Asia, and it traverses the most thickly populated provinces of China. It is over 3000 miles in length and is navigable for 600 miles. It rises in eastern Tibet, and its source is believed to be west of longitude 90°, further west than the sources of the Hoang Ho, Mekong or Salween (chart XXIII).

The Yangtze.

It is known in Tibet as the Di Chu, and as the Dre Chu, and as the Ndu Chu, and as the Murui-ussu. In its Tibetan course it flows eastwards for 500 miles, and then bending to the south it is confined for a great distance between two close parallel ranges, running at right angles to the direction of the Himalaya.

In 1873 Prejevalsky reached a point on the Tibetan course of the Yangtze in latitude 34° 43′ and longitude 94° 48′, and 13143 feet above sea-level: it is here that the two principal Tibetan branches of the Yangtze join, the Napchitai-ulan-muren rising in the Kuen Lun range on the north, the Murui-ussu flowing from a lake from the west. Prejevalsky described the river as a rapid torrent, 5 to 7 feet deep and 750 feet wide; from bank to bank the bed of the river was a mile wide and in the rainy season the whole expanse was under water.*

In 1879 Prejevalsky crossed both the great tributaries above their point of confluence: the Napchitai-ulan-muren he struck in latitude 35° 20′, longitude 93° 10′, and the Murui-ussu in latitude 33° 50′, longitude 92° 20′. He followed an affluent of the latter almost to its source at 16400 feet in the Tangla range.

Part II of this paper (page 110) will have shown how little is known of this Tangla range of Tibet: it is drawn in the frontispiece to Part I in latitude 33°, and it forms the water-parting between the Yangtze and Salween. The Tibetan basin of the Yangtze is bounded by the Kuen Lun range on the north and the Tangla range on the south, and is 250 miles broad.

East of longitude 94° the Baian Kara Ula range separates the basins of the Yangtze and Hoang Ho, and forces the former river to bend to the south.

In 1879 the explorer Kishen Singh crossed the Murui-ussu branch of the Yangtze in Tibet: he described it as flowing in seven channels each about 40 paces wide, the entire river-bed having a width of 800 paces: the greatest depth was 3 feet, and the height above sea-level 14040 feet.†

The Hoang Ho rises about longitude 95° in the trough between the Shuga and Baian Kara Ula ranges. The Shuga range separates the basin of the Hoang Ho from the marshy depression of Tsaidam, and the Baian Kara Ula forms its water-parting from the Yangtze. In this trough the Hoang Ho is divided into two or three channels, each from 70 to 90 feet wide and two feet deep at the fords. Further east it passes through the great Tibetan lakes of Tsaring and Oring, 13704 feet above the sea, and then making a sharp bend to avoid

The Hoang Ho.

* N. Prejevalsky: *Mongolia*, Vol. II, 1876.

† Mr. Hennessey's report *on the Explorations of A-K in great Tibet and Mongolia.*

the snowy Amneh-machin range,* bursts through the chains of the Kuen Lun and hurries on to China proper.† It is known in Tibet as the Ma Chu.

Feeders of the Hoang Ho drain the exterior slopes of the mountain chains, which encircle Koko Nor, the great lake of north-eastern Tibet, but there is no connection between the lake and the river: in one place the water-parting stands only 1000 feet above the level of the lake.

At 3500 feet above the sea the Hoang Ho is 1421 feet broad.‡

* This is perhaps a prolongation of the Shuga range, and in piercing it the Hoang Ho escapes from its original trough after the manner of the Himalayan rivers.

† *Proceedings, Royal Geographical Society,* Vol. IX, 1887. *Prejevalsky's journeys and discoveries in Central Asia, by Delmar Morgan.*

‡ *Prejevalsky.*

21

THE HIMALAYAN RIVERS: INTRODUCTION.

The Himalaya mountains from Afghanistan to Burma are drained by nineteen principal rivers, the drainage areas of which are illustrated in charts XXIV to XXXIV. Chart XXIII furnishes an index to the several river charts. Eight section lines have been drawn across the index chart: they indicate the positions of the eight cross-sections of the great Himalaya given in charts XIV and XV of Part II, and, if scrutinised, they will be found to explain the positions given to the different Tibetan troughs in the cross-sections.

In describing the nineteen rivers of the Himalaya we might have commenced at either end of the range and taken the rivers in their geographical order. It was found more convenient, however, to start from the centre near Simla, and to take the rivers in order, firstly from west to east, and then to return to Simla and to complete the remainder from east to west. By this arrangement the river Jumna comes first (see chart XXIII), and the Ganges second, and when the Brahmaputra has been reached, we return to the Sutlej, and end with the Indus.

Though there may be certain objections to classifying rivers by magnitude, when the limits of the several orders of magnitude are arbitrary, yet it is a course that has many advantages. It corrects erroneous preconceptions, it gives true ideas of proportion, and it helps to save us from the mental confusion that long lists of new and meaningless geographical names are apt to produce.

We have therefore divided the Himalayan rivers into six orders of magnitude, classifying them by the dimensions of the mountainous areas they drain.

TABLE XXX.—The Rivers of the Himalaya.

Name of river.	Order of magnitude.	Himalayan area included in the catchment basin.	Total discharge of water in one year (estimated*).	Ratio of discharge to area, taking that of the Ravi to be unity.
		Square miles.		
Indus	First	103823	9	0·3
Brahmaputra	First	99246	15	0·5
Kosi	Second	23992	8	1·1
Karnali	Second	20623	8	1·1
Sutlej	Second	18554	3·5	0·6

* The numbers in this column do not represent any actual units of measure. The total discharge of the river Ravi has been taken as unity; and the numbers opposite the other rivers show the ratios of their discharges to that of the Ravi. These numbers, it must be noted, are almost all dependent on short observations and rough estimates.

TABLE XXX.—The Rivers of the Himalaya—*contd.*

Name of river.	Order of magnitude.	Himalayan area included in the catchment basin.	Total discharge of water in one year (estimated).	Ratio of discharge to area, taking that of the Ravi to be unity.
		Square miles.		
Gandak	Third	14653	7	1·4
Jhelum	Third	13030	5·5	1·3
Manas	Third	12380	unknown	....
Chenab	Fourth	10588	5·5	1·6
Raidak	Fourth	10161	unknown	....
Ganges	Fourth	8949	5·5	1·6
Kali	Fifth	6318	4	2·0
Beas	Fifth	5663	2·5	1·3
Tista	Fifth	4823	3	1·9
Jumna	Fifth	4546	2	1·3
Ravi	Sixth	3123	1	1·0
Ramganga	Sixth	2611	....	....
Rapti	Sixth	2406	....	....
Baghmati	Sixth	1597	....	....

The discharges of Himalayan rivers have not been sufficiently observed to justify any close study of the results obtained. The discharges of the smaller rivers vary from nothing at all in the hot season to thousands of cubic feet per second in the rains; their beds may remain dry for months, and be flooded for a few days in the year. It is not possible under such circumstances to deduce any average values of daily or monthly discharges. The discharges of the larger rivers that have sources in glaciers never cease entirely, but their variations are yet sufficiently large to render averages meaningless. The discharge of the Indus will vary from 9000 cubic feet a second to a million, and in almost all the Himalayan rivers the maximum discharge is 100 times as great as the minimum. Spasmodic observations of discharges possess but little value: before we can compare two rivers, the diurnal and seasonal and long-period variations in their discharges are required to be known, and these can only be ascertained by systematic measurements.

Nomenclature.

The nomenclature of the rivers of Asia is a source of perpetual trouble. In certain regions the main channel of a river assumes a different name after every bend; Chitral, Asnar, Yasin, Kunar and Mastuj are all names given to the same river. Tashkurgan, Taghdumbash, Dangubash, Sarikol, Karat-chukor, Tisnaf, Chiragh Tar and Almaligh are all names applied to one river. In Ladak the Indus is known by many names: so is the Sutlej. The names Karnali, Gogra, Sarda and Kurriali all belong to one river, and these in addition to its purely Tibetan names.

Where two main affluents join, the combined stream is frequently given a name differing from either tributary, but this system has many advantages to recommend it. Ganges is the name given to the river formed by the junction of the Alaknanda and Bhagirathi, and no one would suggest that any of these three names is superfluous. But to change the name of a main river after its junction with every feeder, or upon its approach to every town, is a course that cannot be justified in geography.

Multiplicity is, however, not the only source of confusion, for whilst it is common for a river to be given many names, it is equally common for the same name to be given to different rivers. The names Sarju, Ramganga, Kali, Dhauli, Kosi, Sarda are all applied to more than one Himalayan river; the great Kali river for instance has the alternative name of Sarda, but the neighbouring river Karnali is also called the Sarda. One of the upper feeders of the Kali in Kumaun is the Dhauli, and the principal affluent of the Alaknanda in Kumaun is the Dhauli. Two rivers rise at a pass in the Alai valley and flow in opposite directions, one towards the east and one towards the west: both are named the Kizil-su. It would be wearisome to mention all the numerous cases of one and the same name being applied to different rivers: instances are to be found in every mountain tract of Asia.

In order to place the geography of High Asia on firmer foundations two reforms in river nomenclature are necessary: *firstly*, we must limit the number of alternative names for a single river; and *secondly*, we must avoid the use of the same name for different rivers. The preservation of every local name is incompatible with scientific geography; the multiplication and repetition of names may not be troublesome to hill men, whose lives are confined to a single valley, but they become unmanageable, when the mountains of Asia are being considered as a whole.

Some native geographical names are undoubtedly of great age, and have been handed down from successive generations. These have to be carefully preserved and their disappearance from maps would be a serious loss; but vast numbers of names after being in vogue for perhaps twenty or fifty years die out, and new names are invented. A traveller, following a Himalayan river, will be astonished at the apparent errors of his fifty-year-old map: many important names on the map, he will see, are unknown to the natives and many names employed by the natives he will not find on the map. His first tendency is to blame the original surveyors and to attribute the discrepancies to their want of care, but the true explanation of the differences is, that the old names have died out and new names have come into existence.

22

THE RIVERS OF THE KUMAUN HIMALAYA.

A separate chart (XXIV to XXXIV) has been drawn to illustrate the Himalayan area drained by each of the principal rivers. Streams have been shown in light blue and boundaries of basins in heavy black lines: the ranges, being facts of deduction rather than of observation, have not been entered, but the highest peaks in each river basin have been plotted, and these indicate the alignments of main axes of elevation.

The thick lines, representing the basin boundaries, are water-partings but not necessarily mountain ranges: the line, for instance, in chart XXXI between the Sutlej and the Karnali crosses a flat plain in Tibet, and that between the Ganges and Jumna in chart XXIV is in nature not a significant feature.

The principal rivers of the Kumaun Himalaya are the Jumna, the Ganges, the Ramganga and the Kali.

The Jumna.

The Jumna (chart XXIV), called also the Jamuna, is supposed to be the Saraswati of the Vedas. On debouching from the mountains it now sweeps round to the south-east, and joins the Ganges at Allahabad; but it is believed to have pursued a westerly course to the Arabian Sea in former times.* The great change in its course may have been caused by alterations in the level of the land west of Saharanpur, or by the constant advance of the sands of the Rajputana desert under the influence of the south-west winds.

Within the mountains the Jumna, like other rivers, flows alternately through narrow gorges and over wide alluvial expanses. Wherever a defile through a range is narrow, the flow of water is retarded above it, and the stream drops its load of gravel and silt; when the gradient and current increase, the stream is able to re-lift its load and to carry it a further stage.

The Himalayan basin of the Jumna has been surveyed, and the courses of its affluents are well-known. The two principal affluents are the Tons and the Giri, the former of which is larger than the Jumna itself.†

The Jumna and the Tons unite in rear of the Mussooree range of the lesser Himalaya, and their combined waters are joined by the Giri in the trough between this range and the Siwalik.

* *A Manual of the Geology of India*, page 450.
† Atlas sheet 48 N.E., 1 inch = 4 miles.

The Jumna is older than the Siwalik range.

The defiles in the Mussooree and Siwalik ranges through which the Jumna passes are directly opposite to one another, and the conclusion is justified that the river was able to deepen its channel and maintain its former course, when the Siwalik range rose across its path.* In crossing the axis of the Siwalik range the Jumna makes a curious bend for a mile or two, and this may perhaps be regarded as evidence that its waters were held in check for a time by the rising range, and had difficulty in cutting a passage. But the barrier could never have been sufficiently high to cause a lake to form behind it, or the Jumna would have taken a south-easterly course across the Dehra Dun and passed the Siwalik range at Hardwar by the gateway created by the Ganges.

A striking feature of the basin of the Jumna is the Chur, an isolated pyramid of the Nag Tibba range of the lesser Himalaya, surmounted by twin peaks. The Chur rises from the interior of the river basin and not from the boundary line.†

The structural trough between the outer Himalaya and the Siwalik range is very distinct on the two sides of the Jumna : on the north-west this trough is known as the Kyarda Dun, and on the south-east as the Dehra Dun.

The Ghaggar.

The outer range of hills west of the Jumna is drained by a small river called the Ghaggar (chart XXIV) ; this stream is of interest, because the Ghaggar is said to have crossed the plains of the Punjab at one time as a considerable river. In the Rajputana desert the wide bed of an extinct river, called the Hukra, can still be traced for miles through the sand and the Hukra may have been a continuation of the Ghaggar.‡ This we cannot decide, but one thing seems certain ; the Ghaggar could never have been a large river, had its Himalayan catchment basin been always as small as at present ; and the question arises as to whether the Giri could formerly have drained into the Ghaggar and given to it the volume of water that tradition ascribes to it.

An objection to this idea is that the Ghaggar is reported to have been a large river within the historic period, whereas the deflection of the Giri,—whether caused by the slow upheaval of a range across its course, or by a feeder of the Jumna cutting back to it south of the Chur and capturing its waters,—must have occurred long before the period of history, if it ever occurred at all.

The Ganges.

The Ganges (chart XXIV) is the great river of northern India that drains the Vindhya mountains and the Kumaun and Nepal Himalaya, and that waters the plains of Rohilkhand, Oudh and Bengal. Regarded as a Himalayan river, the name Ganges is applied to the particular affluent that issues from the mountains at Hardwar.

It was believed by Rennell that the Ganges had a course 800 miles long above Hardwar, and that it drained Kashmir and Ladak ; and these views were represented in his

* United Provinces of Agra and Oudh, sheet No. 1 : 1 inch = 1 mile.

† Atlas Sheet 47, 1 inch = 4 miles.

‡ It may possibly have been a former bed of the Sutlej.

map of India published in 1790. He also thought that the Ganges after draining Tibet passed under the Himalaya through a natural tunnel. "This great body of "water," he wrote, "forces a passage through the ridge of Mount Himalaya, and sapping "its very foundations rushes through a cavern and precipitates itself into a vast basin "which it has worn in the rock at the hither foot of the mountains. The Ganges thus "appears to incurious spectators to derive its original springs from this chain of "mountains, and the mind of superstition has given to the mouth of the cavern the form "of the head of a cow, an animal held by the Hindus in a degree of veneration almost "equal to that in which the Egyptians of old held their God Apis."*

Rennell was relying upon the descriptions given to him by travellers: what he thought was a cavern under the Himalaya was merely the ice-cave at the end of the Gangotri glacier, from which the Bhagirathi issues. Captain Hodgson has described this cave of ice:—† "The Bhagirathi or Ganges issues from under a very low arch at the "foot of the grand snow-bed. The river is here bounded to the right and left by high "snow and rocks, but in front over the debouch the mass of snow is perfectly perpendi-"cular, and from the bed of the stream to the summit we estimate the thickness at "little less than 300 feet of solid frozen snow, probably the accumulation of ages."

By 1807 geographers had begun to doubt the correctness of Rennell's conclusions, and in that year the Government of Bengal authorised a survey of the river Ganges in the mountains to its source. Captains Raper and Webb were directed to "survey the "Ganges from Hardwar to Gangotri, where that river is supposed either to force its way "by a subterraneous passage through the Himalaya Mountains, or to fall over their "brow in the form of a cascade, to ascertain the dimensions of the fall, and delineate its "appearance, and to observe its true geographical situation in latitude and longitude."‡

After following the two great branches of the Ganges until they became narrow torrents, the survey officers reported that the sources of the river were on the southern side of the Himalayan chain. We know now, from modern surveys, that both the Alaknanda and Bhagirathi rise north of the Himalaya and pass through the great range in narrow gorges. The mistake of Raper and Webb is more instructive than that of Rennell: the latter was merely basing conclusions on hearsay evidence; the former actually penetrated and passed the great Himalaya through a stupendous defile carved by the Ganges, but so hemmed in were they by mountains, that they entirely failed to understand that they had crossed the snowy range. From the bed of the Ganges on the northern side of the Himalaya, Raper and Webb reported that they had found the source of the river on the southern side. Mr. Colebrooke summed up the results of the Raper-Webb expedition as follows:—§ "If the Bhagirathi and Alaknanda rivers "had a passage through the Himalaya, it should follow that the channel of its stream "would form the Ghatti (or pass) by which the snowy range became passable. But "since this principle holds good in practice, and since it is utterly impossible to cross the

* *Memoir of a Map of Hindoostan*, 1793.
† *Asiatic Researches*, Vol. XIV, 1822.
‡ *Asiatic Researches*, Vol. XI, 1810.
§ *Asiatic Researches*, Vol. XI, 1810.

"snowy range in a direction which the channels of these rivers might be expected to "assume, I consider that at least all former reports are determined fictitious. No "doubt can remain that the different branches of the river above Hardwar take their "rise on the southern side of the Himalaya or chain of snowy mountains."

In 1812 Moorcroft made a similar mistake: he passed through the great Himalayan range by the valley of the Ganges and crossed the Niti pass into Tibet. The Niti pass is situated on a hinder range, and is thirty miles in rear of the Himalaya; nevertheless when Moorcroft, who was an accurate and capable observer, arrived at the pass, he was quite unaware that he had crossed the Himalaya.*

Such mistakes as these bring home to us what a bewildering maze the unmapped Himalayan area really is. "From an extensive experience in Himalayan surveying," wrote Colonel Tanner, "I can safely state that even when carrying on our work with "the aid of the best maps, instruments and requisite knowledge of surveying, we are "liable, until we compute out the positions of our points, to mistake one mountain for "another, even though we may have learnt their appearance by heart from other "stations."†

Colebrooke's conclusions were held to be correct until the fallacies underlying them were exposed in 1817 by Captain Herbert, who showed that both the Alaknanda and Bhagirathi rise on the Tibetan side of the great Himalayan range.

Feeders of the Ganges.

The Alaknanda has many feeders that rise north of the line of snow, the Dhauli ‡ and the Vishnuganga being the principal. The Dhauli has its source at the Niti pass of the Zaskar range, and the Vishnuganga behind Badrinath: they join at Joshimath (6000 feet) and here the passage through the great range commences (chart XXIV).

At Karnprayag the course of the Alaknanda is deflected by the lesser Himalayan range (Nag Tibba), which also determines the direction of the Pindar tributary. At its junction with the Pindar the height of the Alaknanda's bed is 2600 feet.§

The Bhagirathi issues from the Gangotri glacier behind the Kedarnath peaks at a point called Gau Mukh, 13000 feet high.‖ When Captain Hodgson and Lieutenant Herbert visited Gangotri in 1817, they named four prominent snowy peaks, standing near the head of the glacier, St. George, St. Andrew, St. Patrick and St. David: these names have now fallen into disuse and it would be a pity to revive them: the four peaks of Hodgson and Herbert can be identified with the group, known to modern geographers as Satopanth.

The Jahnavi, the westernmost feeder of the Ganges, joins the Bhagirathi seven miles below Gangotri temple: their combined waters cut through the great Himalayan

* *Asiatic Researches*, Vol. XII, 1818.

† *General Report, Survey of India*, 1883-1884.

‡ Dhauli or Dhauliganga: there are many rivers of this name in the Himalaya, but none as large as this tributary of the Alaknanda.

§ The range south of the Pindar river has on a small scale a resemblance to the Pamir plateau: on the north the Pindar river like that of Tashkurgan flows for a long distance parallel to the range: on the south several rivers, like the affluents of the Oxus, rise in the range and flow down at right angles to it.
Vide Atlas sheet 66 N.W. and sheets of the Kumaun and Garhwal Survey.

‖ Atlas sheet 65, scale 1 inch=4 miles.

range between the peaks of Srikanta and Bandarpunch, four miles west of the former, eight miles east of the latter, and 13000 feet below them (chart XXIV). This gorge of the Bhagirathi is "one of the most remarkable in the Central Himalaya, and for "picturesqueness can hardly be surpassed by any valley in the world. Its sides are "often absolutely vertical, smoothed down by the torrent, which rushes 600 feet or "more down below through a narrow slit in the rocks."*

At Tihri the Bhagirathi has cut down 20 feet into the solid rock below the bed of its tributary, the Behling. This is characteristic of the Himalayan rivers, the development of the trunk streams being commonly in advance of that of the lateral feeders.

The Alaknanda and Bhagirathi unite at Deoprayag in rear of the Mussooree range of the lesser Himalaya, and their combined waters pass the latter through a defile.

The Kaliganga or Mandakini is an important tributary of the Ganges draining the southern faces of Kedarnath and Badrinath (table VI).

The source of the Ganges.

During the earlier half of the nineteenth century controversies frequently arose over the claims of different affluents to be the main source of the Ganges, and Captain Herbert, who was for many years the greatest living authority on the Himalaya, was of opinion that the Jahnavi was the true source.†

It has come however to be recognised that a river, which is being fed from great numbers of glaciers, cannot be referred to any one source, and the question has ceased to be of interest: it is probable that not a twentieth part of the water in the Ganges is derived from any single glacier. If, however, we were to be called upon now to select the most important source of the Ganges, we should not be able to support Herbert's view. Herbert, not having seen the Alaknanda, assumed that the Bhagirathi was the true Ganges, but Sir Richard Strachey has pointed out that the Alaknanda is twice the size of the Bhagirathi, and that, if a source is to be named, it must be the Dhauli.‡

Some writers define the source of a river as the point of its course, that is most remote from its mouth. Colonel George Strahan has shown that if this definition be applied to the Ganges, its source will not be Himalayan at all, but will lie near Mhow in Central India at the head of the Chambal (chart IX).

The following descriptions are taken from Captain Herbert's report on the Mineralogical Survey of the Himalayan mountains.§ "I must not leave the Dhauli, however, "without saying something of those great accumulations of boulder stones, the very "sight of which strikes the traveller with astonishment, and forces him to admit the "action of some great rush of waters. These diluvian beds are here seen on a scale, "which sets at nought any theory that would derive its agent from the body of water "at present occupying that channel."

"The beds of some of the rivers are, for a part of their course, in the solid rock. In "these cases, the depth is often considerable, while the appearance is such as leaves

* *Geology of the Central Himalayas* by Griesbach, *Memoirs, Geological Survey of India*, Vol. XXIII, 1891.

† The name Jahnavi does not now appear on Indian maps, but it is still employed locally though more commonly corrupted to Jadganga. The Jahnavi joins the Bhagirathi at Kopang. Atlas sheet 65.

‡ *Journal, Royal Geographical Society*, Vol. XXI, 1851.

§ *Journal, Asiatic Society of Bengal*, Vol. XI, Part II, 1842.

"not a doubt in the spectator's mind but that the present channel was once filled up "with solid rock. This is a conclusion we cannot escape from however difficult it may "be to understand the removal of so many thousand cubic feet of solid rock by the "agency of water."

"In all the river beds too we see that there are accumulations of gravel and bould-"er stones, all perfectly rounded, and consequently all of them such as have been subject "to the action of water. These collections, it appears from the details I have given, "are in many cases of very great extent, and frequently occur at a height of even 300 feet "above the present bed of the river. That these collections should ever have been "formed by such bodies of water as are found at present in their vicinity, is altogether "inadmissible. Their extent, the size of the fragments, the distance from which they "are derived, above all their great depth, and the height at which they are found above "the present bed of the river—all forbid so incredible a supposition."

Captain Hodgson described how the Ganges was at one time obstructed by the fall of a cliff.* "Five hundred yards further on," he wrote, "are the falls of Lohari Naig "where the river is more obstructed than in any part of its course, and tears its way "over enormous masses of rock, which have fallen into it from the mural precipice which "bounds its left shore. This frightful granite cliff of solid rock, of above 800 feet high, "appears to have been undermined at its foot by the stream, and the lower and middle "parts have fallen into it, while the summit overhangs the base and the river. The "vast ruins of this fall extend for about a quarter of a mile; the river has now forced its "way through, and partly over the rocks with a noise and impetuosity, we thought "could not be surpassed, but on our return in June when the Ganges was doubled in "depth, the scene was still grander."

The Ramganga.

The Ramganga (chart xxv) is an unimportant river, draining the southern face of the lesser Himalayan range in Kumaun.† Its basin has been accurately surveyed.

The principal affluent of the Ramganga is the Kosila or lesser Kosi: it rises in the lesser Himalayan range and does not join the Ramganga, until they have escaped from the mountains and entered the plains.

During the gradual rise of the Siwalik range the Ganges had sufficient water to wear down the growing range and to maintain a direct passage across, but the Ramganga's small volume was unequal to the task of cutting down the new range, as it rose, and the river was deflected by the latter for ten miles to the north-west, before it found a suitable place for an outlet.‡

The structural trough between the lesser Himalaya and the Siwalik range through which the Ramganga flows is known as the Patli Dun: it is of a crescentic shape

* *Asiatic Researches*, Vol. XIV, 1822.

† There are several Ramgangas in the Himalaya, but all are smaller than the one under description.

‡ *Memoirs. Geological Survey of India*, Vol. XXIV, 1890, part 2, page 15.

with the concave side facing south: * it contains immense terraces of gravel of different heights which have been deposited by the Ramganga. "It is," writes Mr. Middlemiss, "one of the most beautiful spots that the North-West Provinces of India can "boast. It is undisfigured by villages and bazars. A solitary forest bungalow is all "that breaks the magnificent monotony of its billowy forests and grass-grown alluvial "flats."†

In its course through the Patli Dun the Ramganga flows parallel to the Pindar tributary of the Ganges at a distance of 45 miles, and at a level lower by 1400 feet.

The trough intervening between the lesser Himalaya and the Siwalik range through which the Kosila flows is known as the Kotah Dun; it is 14 miles long and stretches from north-west to south-east: its level is 750 feet higher than that of the alluvial plains on the outer side of the Siwalik range.

The Kali.

The Kali or Sarda (chart XXV) rises near the Lankpya Lek pass behind the great Himalayan range, and after running for 30 miles parallel to the latter turns and pierces it (figure 2, chart XVI). The height of its bed when it commences to force a passage through the great range is 10000 feet.

The Api-Nampa group of peaks stands immediately east of the Kali: Takachull peak (22661 feet) rises between the Dharma and Gori affluents, and further west on chart XXV, we see the axis of the great Himalayan range marked by Nanda Devi (25645 feet), and Badrinath (23190 feet).

In its upper courses the Kali river and its two affluents the Dharma and Lissar flow in long parallel beds five miles apart. No one of them rises north of the Zaskar range, but the Kali itself appears to flow along a furrow in the crest-zone. The long parallelism of the Kali, Dharma and Lissar rivers in their upper courses shows, perhaps, that minor wrinkles have in this region been superposed on the primary Himalayan folds.‡

The Sarju § affluent of the Kali flowing south-east is on the same alignment as the Pindar tributary of the Ganges;|| for 100 miles these two rivers continue in one line and the beds of both are possibly occupying an original trough created in rear of the Nag Tibba range of the lesser Himalaya when the latter was upraised.

Colonel Tanner describes a remarkable waterfall, which he discovered in the basin of the Kali.¶

"Taking some guides from Garbiang," he wrote, "I went down the Kali instead of ascending the moraine, and after a difficult journey found myself at the bottom of the wildest place I have ever been in. On one side rose the cliff of the moraine backed by the mountains on the right bank

* Atlas Sheet 66 S.W., 1 inch=4 miles.

† *Memoirs, Geological Survey of India*, Vol. XXIV, 1890, part 2, page 55.

‡ "The Lissar river flows during the greater part of its course along the axis of a symmetrical anticlinal formed of carbon-"iferous rocks, leaving it near the end of the Chingchingmauri glacier ...... this anticlinal is flanked on both sides by a "system of other plications more complicated on the north-east." Griesbach's *Geology of Central Himalaya. Memoirs, Geological Survey of India*, Vol. XXIII, 1891.

§ There are many Sarjus in the Himalaya.

|| Compare charts XXIV and XXV, and Atlas sheets 66 N.W., 66 S.W., and 66 S.E.

¶ *General Report, Survey of India*, 1884-85.

of the Kali; opposite towered more cliffs fringed, wherever there was standing room, by forest trees, and down the face of the overhanging scarp in front of me poured the waters from Api in a feathery cascade of great volume and with a fall of between three and five hundred feet."*

"The foot of the fall we could not see, as it descended into a deep abyss, where it was lost in the unseen Kali, which thundered and roared along immediately below our feet, but how far below us we could not say. Sheets of spray filled the cleft of the Kali and were blown hither and thither across the face of the cliffs, and the sun which was well overhead lit up the great hollow at our feet with a mass of bright prismatic colors."

"Having visited this fall, which is called the Yangla Dhar, it was a question whether we should return by the way we had come or try and reach my camp by continuing our journey down the valley of the Kali. We decided on the latter course and though none of my men had previously visited this extraordinary place, they said that there might possibly be a means of skirting the cliffs, but that of course there would be bad places. Bad places there were indeed, and before long when clinging to the rough places in the face of a slope that was nearly a cliff, I fervently wished I had not come, and sometimes had it not been for the friendly grasp of Rinzin's hand, I believe that I should not have emerged safely out of this awful valley. Gradually the dangers of the road became less, and towards evening we reached the most beautiful and charming village of Budi—literally the most delightful place I have seen in the Himalaya."†

"Four valleys converge on Budi; the view of each could occupy an artist for a month. Spreading terraced cornfields skirt the foaming Kali, and here and there on the mountain sides small terraced spots, surrounded with many tinted forest trees, support the quaint houses of the cultivators."

"At one day's march below Budi the passage of the Nirpania-ki-Danda or waterless ridge commences; it has taken the ceaseless toil of generations to construct the series of stone steps or ladders over which the traveller has to make his way for a day and a half before he reaches an ordinary mountain path. This extraordinary trade-route consists of a kind of winding stair-case, which is carried up and down in the face of cliffs in many places overhung with crags and with seemingly an almost bottomless abyss below. The rough steps are built into the rock wherever it has been possible to find foothold."

The Yangla Dhar falls are not true falls in the usual acceptation of the term. When a great river in its course drops suddenly and perpendicularly the drop may be described as "falls;" but the cascade on the Kali is due to the difference in level between the bed of the main stream and the bed of a tributary. The Kali river has cut a deep channel for itself with a perpendicular wall on each side, and it is over one of its lateral precipices that the Yangla Dhar falls occur.

The falls at Kishtwar on the Chenab are also over the face of a side precipice and are not on the main course of the river. Throughout the Himalaya similar cascades can be seen, though rarely so grand as that described by Tanner; trunk streams, that drain extensive trans-Himalayan troughs, deepen their channels at a greater rate than the lateral streams can do, and consequently flow at a lower level at the points of junction. In the higher mountains the differences of level between trunks and their

* For the peak Api, see table VI.

† Atlas Sheet 66 N.E.

branches might be attributed to former glacial action, but this is not possible in the outer hills.

Though there are innumerable cascades throughout the Himalaya only two instances of falls have been recorded ; one is on the Indus where the drop is 20 feet, the other is at Pemakoi on the Brahmaputra, where the drop is 150 feet.

23

THE RIVERS OF THE NEPAL HIMALAYA.

The principal rivers of the Nepal Himalaya are the Karnali, the Rapti, the Gandak, the Baghmati, and the Kosi.*

The Karnali.

The Karnali, called also the Kauriala or Kurriali, is a great Himalayan river (chart XXVI); in its passage across the plains of India after its exit from the hills it is known as the Gogra.†

The sources of the Karnali have been explored by the brothers Richard and Henry Strachey, by Colonel Tanner and by other reliable observers, and its course has been traced in Tibet from Takla Khar to the shrine of Kojarnath; but it then enters Nepal, and with the exception of the information gained by a native explorer, nothing more is known of it, until it reaches the plains of India.

The basins of the Karnali and the Sutlej are in contact in Tibet, behind the basins of the Kali, the Ganges and the Jumna. In escaping from Tibet the Karnali passes through a remarkable trough with Gurla Mandhata (25355 feet) on the one side and peaks of 22000 and 23000 on the other: near Kojarnath this trough is less than 18 miles wide at a height of 20000 feet, a peak of 21800 feet standing eight miles north-east of the river and one of 20300 feet ten miles south-west.

Between Gurla Mandhata and Nampa the Karnali is now creating a canyon similar but inferior to that of the Sutlej.

The great tributary of the Karnali is the Birehi;‡ the two rivers do not unite until they have left the mountains; as their courses in the Himalaya are convergent their delay in conjoining is noteworthy. The two main affluents of the Ganges unite behind the lesser Himalaya range to force a common passage; the tributaries of the Gandak and Kosi do the same; and the Karnali alone of the greater Himalayan rivers possesses two outlets through the lesser range.§

It may be thought that the lesser Himalayan range is but slightly developed across the lower basin of the Karnali, but this is not the case. The number of peaks that have been fixed on one alignment across the basin, and the number of minor rivers that are believed to rise in this alignment are sufficient indications of the presence of a distinct range.

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* Map of Nepal, 1 inch=16 miles.

† For an account of the Karnali see *India*, by Sir John Strachey.

‡ Known as the Birehi in its upper course, as the Babai in its middle, and as the Sarju in its lower.

§ The reference here is to the outer parallel range (Mahabarat) and not to any oblique range.

The following extracts are taken from the diary of a native explorer who followed the upper course of the river Birehi in 1873 from a place called Tibrikot (7226 feet) as far as the Digi pass (16880 feet), which is on the water-parting of the Gandak.

"From Tibrikot I followed the course of the Bheri (*Birehi*) river and reached Charka on the 4th September, having passed some lama-serais on the road. One of them called Barphang Gonpa contains 40 or 50 lamas. Near another named Kanigang Gonpa, the river has high perpendicular rocky banks, and the people have made a tunnel 54 paces in length through the rock. There was originally a crevice, and the rock on either side of it was cut away sufficiently to allow of a man with a load to pass through with a squeezing, the height of the tunnel not being sufficient in all parts to admit of his going through standing."

"Charka is the last village on the river Bheri: on the opposite side of the river is a gonpa (lama-serai) to which the first-born male of every family in the village, as is the practice amongst the Buddhists generally, is dedicated as a lama. I left Charka on the 5th and ascended the Digi La, about 16880 feet above sea-level (called by Goorkhas Balali-Patan) by a gentle incline."

"On either side of the pass there are snow-covered ridges. The pass is broad, and there is a cairn on it at the watershed."*

The Karnali has deepened its bed to a far greater extent than the Birehi. The height of the bed of the Birehi at the point where the river crosses the great range, is believed to be about 6000 feet: the bed of the Karnali is between 3000 and 3500 feet high, where it intersects the zone of great peaks: in its passage across the granite axis of the great Himalayan range the Karnali flows at possibly a lower altitude than any other Himalayan river, excepting perhaps the Indus.

The Rapti.

The sources and course of the Rapti in Nepal have never been thoroughly explored; the maps of the Survey of India show it as rising in the lesser Himalaya and chart XXVI of this paper gives it a small longitudinal basin situated in the outer hills between the Karnali and the Gandak;† but other maps place its sources in the great Himalayan range west of Dhaulagiri. Neither plan has been constructed from surveys and neither deserves much weight.

A river that rises in the lesser Himalaya receives its water from the periodical rains only, and is almost dry for a great part of the year. But a river that is fed by glaciers has a perennial stream. The Rapti is never dry enough in the plains of India to be generally fordable: it is at its lowest in January and February; snow water comes down in May, and the river rises considerably early in June, and remains in flood till September. These facts throw doubt upon the correctness of the Survey of India maps from which chart XXVI has been drawn. In a letter dated September 8th, 1906, Mr. H. Spencer, C.S., writes:—"This year there were two heavy floods in the Rapti "in August simultaneously with unprecedented floods in the Sarju (Birehi) and Kauriala "(Karnali) which unite to form the Gogra. The local rainfall had nothing to do with

* *Explorer's narrative of his journey from Pitcragarh in Kumaon viâ Jumla to Tadum and back along the Kali Gandak river to British territory. General Report, Survey of India,* 1873-74.

The Digi pass is shown on chart XXVI.

† On the authority of the Survey of India, *see* Map of India, scale 32 miles = 1 inch.

"these floods, and it might be inferred that these rivers come from the same tract "of mountain ranges."

The Gandak.

The Gandak has three principal affluents, which have been named by survey explorers the Kali Gandak, the Buria Gandak and the Trisuli Gandak (chart XXVII). Of these three the Kali Gandak is *known*, and the other two are *believed* to rise in the trough behind the great Himalayan range. Having pierced the range independently, they join their waters on its southern side, and in one great stream force an opening through the lesser Himalayan range. It would thus appear that each of the three principal affluents of the Gandak has been able to carve a defile through the greater range, but that all have been stopped and deflected by the rise of the lesser range.

Absence of proper surveys.

The geography of the Gandak basin is, however, so largely theoretical and conjectural, that it is not possible to arrive at definite conclusions. The courses of the great tributaries have been followed by a native explorer, and Colonel Tanner sketched what he could see of the country from great distances: but results obtained by such methods can only be regarded as first approximations to truth, and they will certainly require to be corrected when Nepal becomes accessible to scientific surveys. The following extracts from Colonel Tanner's writings will illustrate his own opinions:—

(i) "From the Someshwar hills which rise at their highest point to a little over 2000 feet, my assistants were able to secure a certain amount of Nepal topography and to fix a considerable number of peaks, but a low range about 20 miles to the north masked all but the snowy range which lay behind it, and no portion of the larger streams such as the Buria Gandak, the Kali and the Trisuli Gandak could be seen."

"The hydrography of this part of Nepal is in considerable confusion, and though we were able to fix with fair precision the upper courses of one or two of these rivers, where the great snow-clad mountains give forth glaciers, yet in the lower ranges their courses have been laid down from the route-surveys of native explorers only, and as some of these route-surveys show a want of completeness in this neighbourhood, the points of junction of the rivers above named remain largely open to doubt. One glance at a tract north of the low range above noted would furnish more geography than could be derived from years of work by explorers; yet I regret to say, access to any point north of the Someshwar range is denied us." *

(ii) "Distant sketching based on trigonometrically fixed peaks affords a fairly good basis whereon to adjust the traverses and topography of the explorers, but it is very difficult work and can only be prosecuted during the very few days in each year, when haze is absent from the atmosphere, and when clouds do not envelop the hill ranges. With the exception of a blank of some ten miles wide which occurs on the west of the Gandak river in Central Nepal, the whole country has been sketched in some form or other, from the towers and other stations of the Great Trigonometrical Survey in the plains and from the hill stations of Kumaun in the west and of Sikkim in the east, but such work being the result in some cases of sketching done from points a hundred miles distant is necessarily vague and incomplete and at the most only secures the tops of the more conspicuous ranges."†

* *Our present knowledge of the Himalaya*, by Colonel Tanner. *Proceed., R. G. S.*, Vol. XIII, 1891, page 419.

† *General Report of the Survey of India*, 1887-88. Notes by Colonel Tanner on *reconnaissances and explorations in Nepal, Sikkim, Bhutan and Assam.*

Names of affluents.

In 1849, Mr. Brian Hodgson wrote of the Gandak as follows* :—

"In the basin of the Gandak we have, successively from the west, the Barigar, the Narayani, the Sweti-Gandaki, the Marsyangdi, the Daramdi, the Gandi and the Trisul. These are the 'Sapt-Gandaki' or seven Gandaks of the Nepalese, and they unite on the plainward verge of the mountains at Tribeni above Saran. They drain the whole hills between Dhaulagiri and Gosainthan, the Barigar and one head of the Narayani rising from the former barrier, and the Trisul with every drop of water supplied by its affluents from the latter. Nor does a single streamlet of the Trisul arise east of the peak of Gosainthan, nor one driblet of the Barigar deduce itself from the westward of Dhaulagiri."

With the exception of the Trisul, Mr. Hodgson's names for the principal affluents differ from those given by the explorers: he obtained his information by questioning Nepalese at Katmandu, and the explorers gained theirs from the inhabitants of the respective localities. It is not uncommon in the Himalaya and Tibet to find a name used for a geographical feature by people at a distance differing from that employed by the local natives.

Exploration of the Gandak basin.

In our description of the Karnali we quoted from the diary of a native explorer who followed up the Birehi tributary to the Digi Pass: this man crossed the Digi Pass, and descending into the basin of the Gandak, reached the town of Kagbeni. Kagbeni is situated at the junction of the Kali Gandak and the Muktinath stream; it is about 9000 feet above sea-level and consists of 100 houses inhabited by Bhotias.

The explorer followed the Kali Gandak to its source at the Photu Pass, and crossed over into the valley of the Brahmaputra. The height of the Photu Pass he found to be 15080 feet above sea-level and 250 feet above the plains of the Brahmaputra to the north. This low depression in the Ladak range is a peculiar feature. It may have been carved by the Kali Gandak in a former geological age, when that river had its sources in Tibet and further north than at present.

Our information concerning the Trans-Himalayan trough of Muktinath is so scanty that the following note by the explorer is of interest: "To the east and south-east of "Muktinath, about two miles, are lofty snowy mountains extending in a north-east "and south-west direction, from which the stream takes its rise which flows by Muk-"tinath to the north, takes in the temple water and joins the Kali Gandak river at "Kagbeni."†

If we are to rely upon the description in this extract, there must be a transverse ridge higher than the snow-line (16000 feet) separating the basins of the Kali Gandak and Buria Gandak north of the Great Himalaya. No observer, however, has actually crossed this ridge, and its existence may be doubted.

The explorer from whose diary we have quoted is the only geographical observer who has ever traversed the defile of the Kali Gandak through the great Himalayan

* *Journal, Asiatic Society of Bengal*, Vol. XVIII, Part II, 1849.

† *General Report, Survey of India*, 1873-74, page xiii.

range. This defile cuts the range 4 miles east of Dhaulagiri peak; the height of the peak is 26795 feet, that of the bed of the defile 5000 feet, and the fall from the one to the other exceeds 5000 feet a mile. The explorer's narrative of his journey along this extraordinary river is disappointing, though not without interest. "On the 5th of "October," he wrote, "no villages were met with during the march, and the road passed "through jungle the whole distance, crossing several small streams running into the "Kali Gandak. I passed the night in the jungle." He was thus unaware that he was crossing the great Himalayan range: he did not see Dhaulagiri and was ignorant of its proximity. His references to the jungle and his failure to notice the rocky precipitous sides of the gorge tend to show that the Kali Gandak possesses a wider passage than many of the Himalayan rivers.

Little is known of the upper courses of the Buria and Trisuli Gandak. In 1865 an explorer marched from Katmandu up the Trisuli Gandak, and passed 15 miles west of peak Dayabhang: he was able to follow the river and did not describe the passage as difficult. He estimated the height of the river's bed, where it crossed the axis of the great Himalaya, to be between 6000 and 7000 feet. He found no open plain nor flat basin behind the great Himalaya, the spurs of the latter being apparently separated by ravines from those of the Ladak range to the north. He crossed a pass (15400 feet) over a ridge behind the great range, and found himself in the basin of the Buria Gandak.

The Buria Gandak rises at the No pass (16600 feet) on the Ladak range: it is possible that the Shorta Sangpo, now a tributary of the Brahmaputra, once flowed over the No pass into the Buria Gandak.

The Buria Gandak and the Trisuli Gandak unite on the south side of the great Himalaya, and after flowing as one river they join the Kali Gandak at Deb Ghat, a goal of pilgrimage. Below the junction of the streams, the explorer stated, the river is called the Narayani; this is one of the names given by Mr. Hodgson in the extract we made from his writings.

The Baghmati.

The Baghmati rises in the Mahabarat range of the Lesser Himalaya, and drains the central valley of Nepal (chart XXVII). This famous valley is a rock-basin filled with alluvial deposits; it is of an oval shape, its greatest diameter being 12 miles and its smallest 9 miles; it is small compared to Kashmir, and unlike the latter is not enclosed between the Great and Lesser Himalaya.

Colonel Kirkpatrick visited Katmandu in 1793, and subsequently published an account of the Nepal valley. In 1805 Colonel Crawford, who was afterwards Surveyor General of India, conducted surveys in Nepal, and measured some of the peaks of the Himalaya, being the first to discover their immense height.* The records of Colonel

* *A Memoir on the Indian Surveys*, by Clements Markham.

Crawford's observations were lost, but a few of his results were given in Buchanan Hamilton's *Account of the Kingdom of Nepal.* From 1805, when Colonel Crawford took observations, to 1903, when Captain Wood was permitted by the Nepalese Government to observe the peaks of Gaurisankar and Mount Everest, no survey officer was allowed to enter Nepal.

The Kosi.

The Kosi (chart XXVIII) is one of the most important of the Himalayan rivers. Its principal affluent is the Arun which drains an immense trough in rear of the great Himalayan range. Chart XXVIII has been taken from the most recent maps of the Survey of India : its main features are probably correct, but it can lay no claim to accuracy of detail.

In the *General Report of the Survey of India* for 1883-84, Colonel Tanner wrote : "I now have to dispose of the various branches of the Kosi river, which wind about "out of view behind the Mahabarat range, and this I confess I am at present unable to "do. Between us, Mr. Robert and I have dotted the country south of the snows with "trigonometrical points, and I can find no room between any of them for a valley "wide enough to contain the western Kosi in its course from west to east."

No additional geographical information has been gained, since Colonel Tanner explained his difficulty, and the course given to the Sun Kosi on the chart is conjectural. All we know is that the tributaries of the Kosi west of Mount Everest are deflected by the Lesser Himalayan range, and that they pass through the latter in the defile carved by the Arun.

The fact that the Arun flows now in a straight course from the great range to the plains shows that it was able to maintain its passage across the lesser range during the latter's growth : the Bhotia Kosi, the Dudh Kosi and all other Kosi affluents were stopped by the rising range, and have had to escape through the gorge forced by the more powerful Arun.

Mr. Brian Hodgson divided the Kosi into seven principal affluents. "The basin "of the Kosi," he wrote, "has seven principal feeders. These are as follows :—the "Milamchi, the Bhotia Kosi, the Tamba Kosi, the Likhu, the Dudh Kosi, the Arun and "the Tamor. Of these the Milamchi rising from Gosainthan is the most westerly and "the Tamor rising from Kangchang (Kinchinjunga) is the most easterly feeder."

"And those two great peaks with the pre-eminent ridges they send forth southwards "include every drop of water that reaches the great Kosi of the plains through its seven "Alpine branches. All these branches, as in the case of the Gandak, unite within the "hills, so that the unity of this Alpine basin also is as clear as are its limitary peaks "and its extent. The Alpine basin of the Kosi is denominated by the Nepalese the "Sapt-Cousika, or country of the seven Kosis."*

* *Journal, Asiatic Society of Bengal,* Vol. XVIII, Part II, 1849. We quote Mr. Hodgson for the information that he gives concerning names : we do not agree with his theories. The basin of the Kosi is not bounded by two great peaks ; it is traversed by a whole line of them. The peaks in the interior of the basin are as high as those on the lateral water-partings. The affluents of the Kosi have not been forced to converge by the ridges running southwards from Kinchinjunga and Gosainthan, but by the recent rise of the lesser Himalayan range across their paths.

It will be seen on chart XXVIII that one affluent is named the Tamba Kosi and another the Tambar Kosi: it is doubtful whether these names are correct. Hodgson mentions the Tamba Kosi, but the Tambar he calls the Tamor; Hooker called Hodgson's Tamor the Tambur, and Montgomerie called it the Tamru.

The Arun Kosi.

The Arun Kosi is a very large river and possesses a considerable drainage area: rising in rear of the great Himalayan range, its eastern feeders encircle Kinchinjunga to the north, and its western feeders drain the northern slopes of Mount Everest.

The eastern branch in rear of the Himalaya is known as the Khantongiri, the Hangtang and the Yaru; the western branch is always called the Arun.

The trough between the great Himalaya and Ladak ranges drained by the Arun is a wonderful example of a structural or tectonic hollow; its length exceeds 200 miles. In no other part of the Himalaya is the trough between these two ranges so clearly defined and so free from transverse ridges or interruptions.* The western portion of this remarkable trough contains the lake of Palgu (15000 feet in height), and the eastern the lake of Tso Motretung † (14000 feet). Neither lake has at present any perennial outlet, but Tso Motretung is surrounded by feeders of the Arun and is believed to overflow occasionally into the Yaru. ‡

The central portion of the trough is drained by the Arun, which has created for itself a gorge of escape through the great Himalayan range between Mount Everest and Kinchinjunga.

In its Trans-Himalayan trough the Arun is 75 paces broad in October, and it meanders over flat plains of alluvium, known as the Dingri Maidan.

Sir Joseph Hooker describes its upper valley as "the broad sandy valley of the "Arun." § Mr. Hodgson once asked a Nepalese soldier if the Dingri Maidan was as large as the Central Nepal valley. "Horsemen," the man replied, "could not gallop "about Nepal; they would have to keep to the roads and pathways. But numerous "regiments of cavalry could gallop at large over the plains of Dingri."||

The height of the plains in the upper valley of the Arun is between 13000 and 14000 feet. The glaciers of Nepal do not now descend below 15000 feet, but there are many proofs that they once occupied the plains of Dingri. Sir J. Hooker describes an ancient moraine, deposited in the upper Arun valley by a former glacier, but now remote from existing ice. "In front," he writes, "close above my tent was a gigantic wall of "rocks, piled—as if by the Titans—completely across the valley for about three-quarters "of a mile. This striking phenomenon had excited all my curiosity on first obtaining "a view of it. The path I found led over it, close under its west end, and wound

* The valley of the Arun is larger than that of Kashmir: a comparison, however, is hardly suitable, as the former is situated in a structural trough on the Tibetan side of the great Himalayan range, whilst the latter is in a trough on the Indian side.

† Tso Motretung was called Chomto Dong in former reports and maps of the Survey.

‡ North-Eastern Frontier Sheet No. 6 N.W., scale 1 inch=4 miles.

§ *Himalayan Journals*, Vol. II, page 167.

|| *Selections from the records of the Government of Bengal*, Vol. XXVII, page 92.

"amongst the enormous detached fragments of which it was formed, and which were "often 80 feet square: all were of gneiss and schist with abundance of granite in "blocks and veins. A superb view opened from the top, revealing its nature to be "a vast moraine, far below the influence of any existing glaciers, but which at some "antecedent period had been thrown across by a glacier descending to 10000 feet "from a lateral valley on the east flank."*

The Bhotia Kosi.

The Bhotia Kosi rises at the Thanglang pass, which is 35 miles north of the crest-zone of the great Himalaya range and 10 miles south of the upper Arun. The height of this pass is 18460 feet: the source of the Bhotia Kosi is thus 5000 feet above the Arun valley to the north, and 6000 feet below the nearer peaks of the great range. The Bhotia Kosi as a river is thus interesting in that it rises behind the axis of the great range, though it has not tapped the trough in rear.

In 1871 a native explorer of the Survey of India crossed the Thanglang pass from the north, and marched down the Bhotia Kosi, and from his accounts the following description was compiled by Colonel Montgomerie:—

"Between Nilam (north of the great range) and Listi Bhansar (south of the range) "the explorer followed the general course of the Bhotia Kosi river, and though it is "but some 25 miles direct distance between the two places, the explorer had to cross the "Bhotia Kosi river 15 times by means of 3 iron suspension and 12 wooden bridges, each "of from 24 to 60 paces in length. At one place the river ran in a gigantic chasm, "the sides of which were so close to one another, that a bridge of 24 paces was sufficient "to span it. Near this bridge the precipices were so impracticable, that the path had "of necessity to be supported on iron pegs let into the face of the rock, the path being "formed by bars of iron and slabs of stone stretching from peg to peg and covered with "earth. This extraordinary path is in no place more than 18 inches and often not more "than 9 inches in width, and is carried for more than one-third of a mile (775 paces) along "the face of the cliff, at some 1500 feet above the river, which could be seen roaring "below in its narrow bed. The explorer, who has seen much difficult ground in the "Himalaya, says he never in his life met with anything to equal this bit of path."†

From Listi Bhansar the explorer's route passed through country characteristic of the Himalaya south of the great range, being extremely rugged for considerable distances, and easy in the troughs or 'duns': he crossed the Indrawati feeder of the Kosi, and found that it drained five small tarns called Panch Pokri.

The Dudh Kosi.

The Dudh Kosi, like the Bhotia Kosi, rises in the great Himalayan range behind the crest-zone and the great peaks. It separates Mount Everest from Gaurisankar, and rises close to the great peak T^{42} (25433 feet).

In 1885 an explorer followed the course of the Dudh Kosi from the south, crossed the Pangula pass at its source and descended into the upper Arun valley behind.

* *Himalayan Journals*, Vol. I, Chap. X. This moraine stood 700 feet above the floor of the valley.

† *General Report on the operations of the Great Trigonometrical Survey of India*, 1871-72.

The Pangula pass he described as the highest and the most formidable one that he had ever crossed; it is 24 miles west-north-west of Mount Everest, and the explorer's route passed within 15 miles of the great peak.* He thus approached nearer to the highest point of the earth's surface than any other geographical observer has ever succeeded in doing: he, however, saw nothing of it, as it was hidden from view by intervening cliffs and ridges.

It has always been regretted that this explorer failed to make any determinations of height: he estimated the height of the Pangula pass at 20000 feet, but no reliance can be placed upon his guesses.

The Tambar Kosi.

The Tambar or Tamor or Tamru is the most easterly affluent of the Kosi: it rises behind the crest-zone of the great Himalayan range, and drains the south-western face of Kinchinjunga and the western slopes of the Singalila ridge. The peaks of Jano and Kambachen stand within its basin, and the glacier of Yalung feeds its waters.

* *General Report of the Survey of India*, 1885-86.

24

THE RIVERS OF THE ASSAM HIMALAYA.

The principal rivers of the Assam Himalaya are the Raidak, the Manas and the Brahmaputra: the Tista has been included with them in this section, but it is the river of Sikkim, and does not enter Assam. Sikkim is the name given to the Himalayan area drained by the Tista; it is situated at the junction of the Nepal and Assam Himalaya, and separating the two belongs to neither. Some writers have referred to the mountains of Sikkim as the Sikkim Himalaya, but in this paper we have endeavoured to limit the numbers of Himalayan divisions, and as Sikkim is a very small area, we have regarded the bed of the Tista as the eastern boundary of the Nepal Himalaya and as the western boundary of the Assam Himalaya.

The Tista. *

Compared with the basins of other Himalayan rivers that of the Tista possesses exceptional features (chart XXVIII). The Lesser Himalayan range and the Siwalik range seem both to be absent, and the great Himalayan range has been cut back into a bay instead of being pierced by a river gorge. †

The great Himalayan range trends from Kinchinjunga to Chumalhari, but it may be questioned whether its alignment between the two peaks was originally straight. It is possible that the great range was slightly curved east of Kinchinjunga. But whether the Tista originally flowed down from a straight range, or whether its development was assisted by a concave bay in the range, there is but little doubt that it has succeeded in cutting back through the great Himalaya by head erosion, and that its sources are now situated behind the original line of crest.

The Tista rises on the northern side of the Himalayan crest-zone, but not north of the range itself, and it does not drain any structural trough in rear of the range as the Arun does. The drainage of the northern slopes of the Kinchinjunga mass, though not of the supreme summit, passes into the Arun.

The basin of the Tista has probably a heavier rainfall than any other Himalayan basin; not only is it situated at the head of the Bay of Bengal but there are no outer ranges of mountains to bar the progress of the moisture-bearing winds.

On issuing from the mountains the Tista flows near the water-parting between the alluvial basins of the Ganges and Brahmaputra: formerly its course in the plains was southwards and it joined the Ganges at Jaffirganj, but in 1787 it suddenly changed its direction and opened out a new channel to the eastward, in which it has since flowed, joining the Brahmaputra above Divanganj.‡

* Much interesting information concerning the Tista and many beautiful views of Sikkim will be found in Douglas Freshfield's *Round Kangchenjunga.*

† North-East Trans-frontier Sheet, 7 N. W., 1 inch = 4 miles.

‡ *Rudiments of Physical Geography,* by H. F. Blanford.

From Sir Joseph Hooker's descriptions of the Tista it would appear that it does drain a *comparatively* level valley in rear of the great granite range, though not a tectonic trough. "Above 11000 feet," he wrote, "the valley expands remarkably, the "mountains recede, become less wooded and more grassy, while the stream is suddenly "less rapid, meandering in a broader bed and bordered by marshes."*

"The upper portion of the course of the Tista (Lachen-Lachoong) is materially "different from what it is lower down, becoming a boisterous torrent as suddenly as "the Tambur does above Mywa Guola. Its bed is narrower, large masses of rock "impede its course."†

"From its principal source at lake Cholamo it descends from 17000 to 15000 feet "with a fall of 60 feet to the mile; from 15000 to 12000 feet the fall is 140 feet to the "mile; in the third part of its course it descends from 12000 to 5000 feet with a fall "of 160 feet to the mile: and in the lower part the descent is from 5000 feet to the "plains of India at 300 feet giving a fall of 50 feet to the mile. There is, however, no "marked limit to these divisions; its valley gradually contracts, and its course gradually "becomes more rapid."‡

Sir Joseph Hooker calls attention also to the remarkable absence of large stones or boulders from the bed of the Tista.§

The Raidak and the Manas.

The Himalayan area drained by the Raidak and Manas is known as Bhutan (chart XXIX). The positions and heights of a few peaks in the basins of these rivers have been fixed, and the courses of the main streams followed; but observations have been insufficient to justify any definite statements, and to a great extent the country is a *terra incognita*.||

"In Bhutan," wrote Colonel Tanner in 1891, "all the rivers can be set down "as unknown, except the Lhobrak of Tibet, which emerges into India as a part of those "large rivers which, united, form the Manas of the plains."¶

Captain Pemberton traversed Bhutan from west to east in 1838, and he discovered that there were several passes leading from Tibet into the basin of the Manas.

The interesting feature in the geography of the Raidak is that the hill rivers flow out independently parallel to one another and perpendicularly to the ranges, instead of combining behind one of the outer ranges to force a joint passage. The reason of this peculiarity is that the outer Himalayan and Siwalik ranges are not represented by any marked chains of mountains in the basin of the Raidak.

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* *Himalayan Journals*, Vol. II, page 66.

† *Himalayan Journals*, Vol. II, page 15.

‡ *Himalayan Journals*, Vol. II, page 399.

§ *Himalayan Journals*, Vol. I, page 397.

|| For exploration of the Manas basin, see *General Report, Survey of India*, 1866-67.

¶ *Proceedings, Royal Geographical Society*, Vol. XIII, 1891, page 416.

In the Manas basin the lower ranges re-appear and gain their normal elevation, and the phenomenon of rivers converging and uniting in the mountains is again witnessed.

The valley of Chumbi is drained by the Ammu tributary of the Raidak, and consequently forms part of the basin of the latter.* This valley is the only portion of the Himalayan area south of the great range, that belongs to Tibet. The rainfall in Chumbi is very small compared to that of the contiguous province of Sikkim.

The Brahmaputra.

The basin and tributaries of the Brahmaputra are shown in chart XXX: this river rises near the sources of the Karnali and Sutlej in Tibet at a height of 16000 feet. Unlike the Indus, or Sutlej, or Karnali, it has cut no deep channel for itself in Tibet, and in spite of its immense elevation it is, south of Lhasa, a sluggish and navigable river. Its basin is nowhere in contact with that of the Indus. Its bed is 14840 feet high at Tradom, 11800 feet at Shigatze, 8000 feet at Gyala Sindong and 442 feet at Sadiya in Assam.

Change in direction of flow.

The remarkable feature of the Brahmaputra in Tibet is the tendency of its feeders to flow in a direction opposite to that of the trunk river. † If but one feeder had been observed to take a course contrary to that of the river, the phenomenon might have been attributed to some local topographical peculiarity; but when all the principal affluents of a long section of the river are found to follow the same contrary course, it becomes evident that the Brahmaputra must at no distant time have flowed from east to west in Tibet, and that its tributaries were developed during that period of its history.

It has been held by some authorities that the Brahmaputra has been diverted from an original course through China, and has been forced to cut a passage through the Assam Himalaya.‡ But in our opinion the evidence furnished by its feeders is conclusive; the Brahmaputra formerly flowed through Tibet from east to west. It is not possible to express an opinion at present as to where it escaped through the Himalaya: it may have flowed over the Photu pass and through the defile of the Kali Gandak; it may have passed through the basin of the Karnali, and it may have followed the present Himalayan course of either the Sutlej or the Indus: arguments can be adduced to show that each of these hypotheses is worthy of future investigation, but with our present knowledge no conclusion can be reached. §

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* North-East Frontier Sheet, 7 N. W., 1 inch = 4 miles.

† *Annual Report of the Board of Scientific Advice for India*, 1905-06.

‡ *India, by Sir T. Holdich*, 1905, page 111.

§ The following evidence supports the idea that the Brahmaputra once escaped from Tibet along the present course of the Kali Gandak. The Photu pass separating the basin of the Kali Gandak from the present basin of the Brahmaputra is an extraordinary depression in the Ladak range and is only 250 feet higher than the Brahmaputra plains of Tibet. The gorge of the Kali Gandak intersecting the great Himalaya is immensely deep and can hardly have been cut by the volume of water issuing from so small a catchment basin, as the river now possesses behind the great Himalaya.

That the Brahmaputra once flowed out from Tibet by the channel of the Sutlej is an hypothesis that helps to explain the present existence of the great canyon in Tibet; the small stream that now trickles along the floor of the canyon cannot have sufficed to cut such a mighty ravine. The course of the Sutlej in Tibet follows the same alignment as that of the Brahmaputra, and the channels of the Spiti and the Chenab are further extensions of the same line. (*continued on next page*).

Of the great rivers of the world, the Brahmaputra furnishes the only instance of drainage flowing in a diametrically opposite direction to what it formerly did, though still occupying the same bed.

The principal Tibetan tributaries of the Brahmaputra, that may be observed to flow against the present river, are :—

(*i*) The Kyi, or Lhasa river.
(*ii*) The Nyang, joining the Brahmaputra at Shigatze.
(*iii*) The Rang.
(*iv*) The Shang.

Many smaller feeders adopt contrary courses also.

The most recent maps show that shortly before their junctions with the Brahmaputra, these tributaries are beginning to bend in their courses, and to turn towards the present direction of the Brahmaputra's flow, and in their future development they will doubtless adapt themselves to the altered conditions.

The Nyang tributary.

The Nyang tributary rises near two lakes north of Chumalhari, forces its way through the Ladak range, and falls into the Brahmaputra near Shigatze.* It is the only Tibetan tributary of the Brahmaputra that drains the great Himalayan range, and the only river east of Manasarowar that pierces the Ladak range. The peculiar bay, which is to be noticed in the water-parting on chart XXXV between Kinchinjunga and Chumalhari, is due to the passage of the Ladak range by the Nyang river. The Arun, the Kali Gandak, the Birehi and others rise in the Ladak range and pierce the great Himalaya, the Nyang rises in the great Himalaya and pierces the Ladak.

The Kyi and Raga tributaries.

The Kyi or Lhasa river rises in the Ninchinthangla range, and forces a passage through the Kailas range.

The frontispiece chart shows how the Kailas range bifurcates in Tibet: it is this bifurcation that gives rise to the Raga river.

Yamdrok lake.

The great lake of Yamdrok is situated at a distance of five miles from the Brahmaputra: it is confined between two ranges, the Ladak range to the south and the branch of the Kailas to the north.† The level of water in the lake is 14350 feet, that of the bed of the Brahmaputra opposite to it is 11700 feet, a fall of 2650 feet in five miles. In the range separating the lake from the river is a notch 15400 feet high,—about 1000 feet above the level of the lake. It is doubtful whether any connection exists between this lake and the Brahmaputra ;‡ the water of the lake is believed to flow westwards by an

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The belief that the Brahmaputra was formerly an affluent of the Indus in Tibet rests only upon the great depth to which the Indus has cut down its bed in Tibet. The bed of the Sutlej at its exit from Tibet is 10000 feet high, that of the Brahmaputra is 8000 feet, but that of the Indus is only 4600.

The suggested explanations of the former course of the Brahmaputra are the merest conjectures; it will be noticed that they all depend upon the tacit assumption that existing streams cannot have accomplished the work of erosion that has been accomplished. We possess however no sufficient data upon which to build estimates of the eroding power of streams acting through millions of years, and seeing that Tibet once possessed a moist climate, we are not warranted in assuming that the volume of water discharged by rivers has never been larger than at present.

* North-East Frontier Sheets, 6 N. W., and 6 S. W., 1 inch = 4 miles.

† North-East Frontier Sheets, 6 N. E., and 6 S. E., 1 inch = 4 miles.

‡ *See* Ryder's notes, *General Report, Survey of India*, 1903-1904, Appendix, p. xviii.

underground channel into the Rang tributary. For many years it has been an open question whether the lakes of Manasarowar ever overflow into the Sutlej, and the connection between Yamdrok and the Brahmaputra presents a similar problem.

The identity of the Sangpo and Brahmaputra.

The Tibetan portion of the Brahmaputra was formerly known in geography as the Sangpo. For many years uncertainty prevailed as to whether the Sangpo flowed into the Brahmaputra of Assam, or into the Irrawaddy of Burma. The idea that the Irrawaddy was the debouchment of the Sangpo originated with D'Anville and the Chinese surveyors. Their view was maintained by Dalrymple, the author of the Oriental Repertory, and by Klaproth, but it was opposed by Rennell in 1793. In 1885 it was revived and ably argued by Robert Gordon, but was combated by General Walker, who was one of Rennell's successors as Surveyor General at Calcutta.* The problem was solved by the explorations of Pandit Kishen Singh, and it is now known for certain that the Sangpo of Tibet is the upper course of the Brahmaputra.

A brief account of the exploration of the Brahmaputra in Tibet.

The existence of the Sangpo river of Tibet first became known to western geographers through D'Anville's maps, which were compiled from surveys made at the beginning of the eighteenth century by Chinese lamas. The river was actually crossed by Bogle on his way to Lhasa in the year 1774, and a few years later by Turner and Manning.

It was about 1860 that Colonel Montgomerie first commenced to train natives of the Himalaya in the rougher branches of surveying and to work out his plan for the systematic exploration of Tibet and Central Asia. In 1865, Pandit Nain Singh, one of Montgomerie's explorers, penetrated through Nepal to Lhasa, crossing the Brahmaputra at Tradom: this was the first occasion on which an Indian surveyor had seen the Sangpo river of Tibet. Nain Singh returned from Lhasa to India *viâ* the Manasarowar lakes: he estimated that the average height of the road between Lhasa and Tradom was 13500 feet and between Tradom and Manasarowar 15000 feet.†

He discovered that the great river flowed in a south-easterly direction for about 170 miles, and thence adhered very closely to a due east course for at least 500 miles more: at 600 miles from its source he measured its discharge, which he found to be 35000 cubic feet a second in December. "The navigation at 13500 feet above the sea," wrote Colonel Montgomerie, "rude though it may be, is an extraordinary feat: "navigation of any kind at such an altitude being quite unknown in any part of either "the old world or of the new. If the Pandit had any doubt as to the great volume of "the river it was completely removed by a squall which suddenly swept across the broad "expanse of water; the wind raising such large waves that the small fleet of boats "carrying the Pandit and his companions only escaped swamping by taking to the "nearest shore."

* *Proceedings, Royal Geographical Society*, Vol. VII, 1885.

† *Report of a route survey made by Pandit Nain Singh* by Captain T. G. Montgomerie, R.E. Tradom is in longitude 84° 15': Northern Frontier sheet 22 N. W.

In 1874, Pandit Nain Singh started from Leh in Western Tibet, and marched over 1200 miles of previously unknown country. He reached Chetang, a town on the Brahmaputra, 50 miles east of Lhasa. At Chetang, the lowest point on the course of the Brahmaputra in Tibet that had up till then been visited by an explorer, the Pandit found the width of the river to be 500 yards; the stream was very sluggish and the depth of the water nowhere more than 20 feet. On the left bank of the river was an expanse of sand, one and a half miles wide, which was said by the Tibetans to be under water during the river floods of the summer.*

In 1875, an explorer named Lala traced the Brahmaputra from Shigatze to Chetang, but went no further eastwards than Nain Singh had done.

Nem Singh.

In 1878 Lieutenant Harman, R.E., trained a Bhutia explorer, named Nem Singh,† and sent him to Chetang with orders to survey the course of the river eastwards. Nem Singh was able to follow the Sangpo to a place called Gyala Sindong (chart XXX) which was 200 miles from Chetang: 120 miles below Chetang the explorer found the river still very sluggish, but it was now only 250 paces broad and had become considerably deeper. To Gyala Sindong Nem Singh gave the height of 8000 feet.‡

The exploration of the Dihang.

The largest tributary of the Brahmaputra in Assam is the Dihang; and it had been generally recognised by geographers, even in the early part of the nineteenth century, that if the Sangpo of Tibet did flow into the Brahmaputra of Assam, it must come by the course of the Dihang—it must in fact be that tributary of the Brahmaputra, which was called in Assam the Dihang.§

Gyala Sindong, situated on the Tibetan side of the Himalaya, was only 100 miles distant from a point which had been fixed on the Dihang on the Assam side of the Himalaya. Nem Singh was told by the Tibetans at Gyala Sindong that the Sangpo after flowing through the mountains entered a land ruled by the British.||

In 1880, a Chinese Lama of Giardong was despatched by Captain Harman to explore the Sangpo below Gyala Sindong, and to follow the great river through the Himalaya to the plains of India. If he was unable to penetrate the mountains, he was directed to throw marked logs into the stream at the lowest point reached, and Captain Harman arranged that men should always be watching the Dihang river in

* *Report on Trans-Himalayan Explorations*, 1873-74-75, *Great Trigonometrical Survey of India.*

† The G. M. N. of the Indian Survey.

‡ *Report on Trans-Himalayan Explorations in* 1878.

§ Harman found that the Dihang had a minimum discharge in Assam of 55500 cubic feet per second, or four times that of the Subansiri tributary and twice that of the Dibang (chart XXX).

Discharge of	Cubic feet per second.
Dihang	55500
Lohit and Tenga	33800
Dibang and Sesiri	27200
Subansiri	16000

|| *General Report, Survey of India*, 1878-79.

Assam for the arrival of the logs. The identity of the great river of Tibet with the Brahmaputra would then be proved.

Kinthup, a native of Sikkim, who had previously accompanied the explorer Nem Singh to Gyala Sindong, and had been employed on explorations in Bhutan, was sent with the Chinese Lama as his assistant. Captain Harman's plans were upset by the treachery of the Lama, who sold Kinthup as a slave in the Pemakoi country and decamped to his home in China. Kinthup on regaining his freedom followed the Sangpo down from Gyala Sindong and reached a place called Onlet (chart XXX). Onlet is only a few miles from Miri Padam, the abode of the Miri and Padam tribes, who are known to inhabit the country near the place, where the Dihang breaks through the hills into Assam. Kinthup was informed at Onlet that Miri Padam was 35 miles from the plains of India.* The Sangpo of Tibet was thus traced to Onlet, which is less than 50 miles from the place where the Dihang passes out of the Himalaya into Assam. "I conceive," wrote Colonel Tanner, "that no further doubt should remain "even in the minds of the most sceptical as to the identity of the great river of "Tibet with the Dihang."†

In 1881, the explorer Kishen Singh, proceeding from the east, crossed the water-parting between the Salween and the Brahmaputra, and entered the horse-shoe shaped basin of the Zayul, the easternmost feeder of the Brahmaputra (chart XXX). He travelled down the bed of the Zayul to Sama which is only 100 miles from Sadiya in British territory, but being prevented from entering Assam he had to retrace his steps.‡

Near Pemakoi, ten miles below Gyala Sindong, the Sangpo has a vertical drop in its bed, and here occur the only considerable falls, which have been discovered on the trunk stream of a Himalayan river.

The falls of the Brahmaputra.

Kinthup described these falls of the Sangpo as follows:—"The Sangpo is two "chains distant from the monastery, and about two miles off it falls over a cliff "called Sinji Chogyal from a height of about 150 feet. There is a big lake at the foot "of the falls, where rainbows are always observable."§

Geographers have predicted that great falls would be discovered on the Sangpo between Gyala Sindong and Assam, but there are no real grounds for such a belief. The average fall of the Sangpo below Gyala Sindong to Assam is no greater than that of numerous other Himalayan rivers, on none of which are great falls to be found. Chart XXXVII has been drawn to show that the further a river rises behind the great Himalaya, the less prospect is there of great falls being discovered on its course: rivers that rise on the south side of the great Himalaya experience the severest drop, whilst rivers, like the Brahmaputra, that rise in Tibet have an easier fall than the Arun, the Kali Gandak, or the Alaknanda.

* *Account of Trans-Himalayan Explorations, General Report, Survey of India*, 1886-87.

† *General Report, Survey of India*, 1886-87.

‡ *Mr. J. B. N. Hennessey's Report on the Explorations of A-K in* 1879-82.

§ *K-P's narrative*, translated by Norpu.

In 1877 Captain Woodthorpe penetrated the mountain basin of the Subansiri: this tributary of the Brahmaputra was supposed at one time to be the continuation of the Sangpo of Tibet, but there is no evidence tending to connect the two, and as a river it is very inferior to the Dihang.

The Subansiri.

"That the Subansiri," wrote Captain Woodthorpe, "rises behind the high snowy "peaks seen from Tezpur, I think very likely from its size and velocity, but its volume "is only one-fourth that of the Dihang. The Subansiri is a noble river in the hills, "and the gorges through which it emerges into the plains are singularly fine: the banks "are formed of precipitous masses of rock enclosing deep pools, in which measurements "give a depth of 70 and 80 feet: the river is about 70 yards broad at Ganditula and "flows with great velocity."*

A trunk stream is almost always joined by a large tributary at the point, where it bends to pierce a range. The Gilgit river joins the Indus near the knee-bend of the latter above Bunji: the Maru Wardwan joins the Chenab near the knee-bend at Kishtwar: similarly the Spiti joins the Sutlej near its bend, and a large eastern affluent joins the Arun. But so far no great tributary has been found to join the Brahmaputra in Tibet at the point where it bends above Gyala Sindong.

Comparisons with other rivers.

The Sutlej in issuing from Tibet pierces the border range of mountains within 4½ miles of Leo Pargial, the highest peak of its region; the Indus when turning the great Himalayan range passes within 14 miles of Nanga Parbat, the highest point of the Punjab Himalaya; the Hunza river cuts through the Kailas range within 9 miles of Rakaposhi, the supreme point of the range. It will form an interesting problem for investigation whether the Brahmaputra of Tibet has cut its passage across the Assam Himalaya near a point of maximum elevation.

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* *General Report, Survey of India*, 1877-78.

25

THE RIVERS OF THE PUNJAB HIMALAYA.

The Punjab Himalaya is the name given to that portion of the great range which lies between the Sutlej and the Indus. Its principal rivers are the Beas, the Ravi, the Chenab, and the Jhelum. With these we have included the Sutlej as a Punjab river. but have reserved the Indus for a separate section of this paper.

*The Sutlej.**

The mountain basin of the Sutlej (chart XXXI) lies mainly north of the Himalaya; the area of the Himalaya proper drained by this river, between the great range and the plains of India, consists of an insignificant transverse strip, and it is an interesting problem to study how it can have come about that such a great river drains such a narrow zone in its Cis-Himalayan course.

Narrowness of its basin.

The Sutlej is bounded on the east by the water-parting of the Giri (Jumna) and on the west by that of the Beas: at corresponding points in the mountains the beds of the Giri and Beas are relatively higher by 600 or 700 feet than that of the Sutlej, so that the latter is running along a deeper trough than the rivers on either side of it. Increased depth of trough means steeper slopes, and steeper slopes give to the tributary streams greater erosive power. The mountains should therefore be more rapidly denuded by the feeders of the Sutlej than by those of the Giri or Beas, and the basin of the Sutlej in the outer Himalaya should now be slowly widening—the eastern water-parting retiring towards the Giri, the western towards the Beas. The fact that the Sutlej has no Cis-Himalayan tributaries comparable to those of the Jumna or Beas tends to show that it is the youngest river of the three. Whether these speculations are correct or not, the question as to how the Giri and Beas have confined their giant neighbour to a trough less than 20 miles wide remains worthy of consideration.

The Sutlej rises in the distant high-lands of Tibet, and possesses a very long course through the mountains. The Trans-Himalayan portions of its basin, however, receive but little rain, and table XXX shows its annual discharge to be small.

The sources of the Sutlej.

Much of the rainfall in the higher Himalayan valleys is said to be due to moist winds rushing up the mountain passages cut by the rivers. The rain-bearing winds of the monsoon blow from the Bay of Bengal across the Gangetic plains, and the valley

* Known as the Sutluda by natives of the hills.

of the Sutlej, lying as it does at right angles across their path, is not favourably placed for their reception.

In drawing chart XXXI to illustrate the catchment area of the Sutlej, we were in doubt whether to include the lake basin of Manasarowar; we eventually decided to do so, and will now briefly discuss the evidence available.*

A great number of streams flow down from surrounding mountains into the two Manasarowar lakes, and the water of the eastern lake (Manasarowar) overflows into the western (Rakas Tal) (chart XXXI).

The connection between the two lakes was discovered by Henry and Richard Strachey in 1846, and has been confirmed by other reliable observers. "We came," wrote Henry Strachey, "to a large stream 100 feet wide and 3 feet deep, running rapidly "from east to west through a well-defined channel: this was the outlet of Manasaro-"war. It leaves that lake from the northern quarter of its western shore, and winding "through the isthmus of low undulating ground, for four miles perhaps, falls into "Rakas Tal."†

Fifty-eight years later the same channel was visited by Major Ryder, and he has given the following description: "We struck the channel a mile below the outlet, a "small stream only partly frozen over; this we followed up and found that it did not "flow from the lake but from a hot spring, at which we found and shot some mallard. "We then followed up the dry nullah to the lake and proved that Strachey was, as was "to be expected, quite correct. No water was flowing at this time of the year, but the "local Tibetans all agreed that for four months in each year there was a flow during the "rainy season and the melting of snows, *i.e.*, about from June to September. As a rise of "about 2 feet in the level of the lake would cause water to flow down the channel, this "appears quite worthy of belief."‡

The connection between the two lakes may be taken as established, but that between the western lake and the Sutlej basin is still open to question. The following is Henry Strachey's description: "There is no visible channel from the lake, and the only effluence "is by filtration through the porous soil of the intermediate ground, unless it be at times "of extreme flood, when the level of the lake may possibly rise high enough to over-"flow the margin."§

Richard Strachey wrote as follows: "A stream, the head of which we visited, "flows from Manasarowar into Rakas Tal, and the latter occasionally, when high, sends "off a feeder into the Sutlej."||

Captain Rawling refers to the question in his book *The Great Plateau*, which was published after his visit to the lakes in 1904. "It is evident," he writes, "that no "water had flowed from Rakas Tal down the passage for a considerable time, but there

* Northern Frontier Sheet 14 S. W., 1 inch = 4 miles.

† *Journal, Asiatic Society of Bengal*, Vol. XVII, 1848.

‡ *Report on Survey operations with the Tibet Frontier Commission*, 1904.

§ *Journal, Asiatic Society of Bengal*, Vol. XVII, Part II, 1848.

|| *Journal, R. G. S.*, Vol. XXI, 1851.

"was nothing here to prove that such might not be the case during the melting of the "snows in an exceptionally wet season."

The following further extract is taken from Major Ryder's report.* "We found "an old stream bed issuing from the Rakas Tal, but every Tibetan we asked told the same "story, that no water ever flowed along it now, but in days gone by, one man saying "before the Sikh war, water did flow out of the lake and down this channel. We followed "it down for some six miles along the plain, and could find none of the ordinary signs "of water flowing down it, until we reached some low hills; here evidently from the lie "of the sand, water flowed at some time of the year and away from the lake."

If the water of the Manasarowar lakes overflows *occasionally* into the Sutlej, they must be regarded as belonging to the basin of the latter. We define a basin as the whole tract of country drained by a river and its tributaries: by the word "drained" we do not imply any perpetual flow, but refer only to times of rain and flood. All the small tributaries of the Himalayan rivers are dry at certain times of the year, but a dry tributary remains a branch of the drainage.

If the water from Rakas Tal flows into the Sutlej once a century, and then only for such a short period as to be observed by no one, we shall still be justified in including the lakes in the catchment area of the river.

Subterranean drainage.

Henry Strachey was probably right in thinking that the water of the lakes filtered through the porous soil: examples of such filtration are common in the alluvial valleys of the Himalaya. Rivers disappear and subsequently re-appear at the surface. In the underground observatory of the Trigonometrical Survey at Dehra Dun water accumulates in the subterranean drains after heavy falls of rain in the neighbouring hills, even when no rain has fallen locally; the intervening river bed remains dry, and the water flows along an underground course. These underground systems of drainage seem to follow closely the beds of surface streams. The latter hold water only when the volume of flood is too large to sink into the ground, but when the surface is dry, there is often a flow at a lower level.

The course of the Sutlej in Tibet.

From Rakas Tal to Shipki, at the base of Leo Pargial, the Sutlej takes a north-westerly direction through the Tibetan province of Nari Khorsam.† The best known portion of Nari Khorsam is the plateau situated between the Zaskar and Ladak ranges. This plateau is 15000 feet in height. It has been formed by successive deposits of boulders, gravel, clay and mud in the trough between the two ranges; the deposits lie in parallel and nearly horizontal beds. Nari Khorsam furnishes in fact another example of the common Himalayan type of rock valley filled up with recent alluvium.‡

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* *Report on Survey operations with the Tibet Frontier Commission*, 1904.

† *Nari Khorsam* is the Tibetan name: *Hundes* is the name used by natives of the Himalaya.

‡ Map of Nari Khorsam, 1 inch=8 miles. Atlas sheet 65, 1 inch=4 miles. Northern Frontier sheet, 9 N. E., 1 inch =4 miles.

In one part of Nari Khorsam the water-parting between the Sutlej and Karnali traverses the level plain of alluvium, and a man can walk from one river to the other without crossing a hill of any sort.

In its course through Nari Khorsam the Sutlej has gradually cut into the unconsolidated deposits and has created an extraordinary canyon—a canyon that bears comparison even with the famous American canyon of Colorado. The Jhelum has created no canyon in Kashmir because the rainfall over the basin is sufficient there to lower gradually the whole alluvial area; but Nari Khorsam is an arid region, and whilst the Sutlej has been able to excavate a channel 3000 feet deep through the plateau by means of water received from the glaciers of Kailas, no rain has fallen locally to erode its perpendicular cliffs.

The Sutlej is joined by several tributaries in Nari Khorsam, the beds of which lie 1000 feet or more below the surface of the plain: their overhanging cliffs like those of the Sutlej have been spared from destruction by rain, and flat portions of the plateau now remain standing between profound gorges.

The water-parting between the Sutlej and the Indus in Nari Khorsam is the Ladak range with peaks of 19000 and 20000 feet. Twenty-five miles north-west of Manasarowar feeders of the Sutlej have cut back through the Ladak range into the trough behind; the water-parting between the Sutlej and Indus is at this point as low as 16200 feet, only 900 feet above the Indus near Gartok.

The passage of the Sutlej through the Zaskar range is near Shipki and within 4½ miles of the summit of Leo Pargial, the highest peak on this part of the range: the proximity of the gorge to the peak is a striking phenomenon. The height of Leo Pargial is 22210 feet, that of the bed of the gorge 10000 feet, a difference of 12210 feet. Ten miles below Shipki the right bank of the Sutlej is a perpendicular wall of rock 6000 or 7000 feet in height.*

The Spiti river.

The principal tributary of the Sutlej is the Spiti river, which drains a large area behind the great Himalayan range. Its bed lies deep below the alluvial terraces, and its water is consequently rarely available for cultivation. The terraces are stratified deposits of gravel and sand, and rise to a height of 400 feet above the river: on the terraces rest immense accumulations of débris which have fallen from the surrounding mountains. The basin of Spiti like that of Kashmir is surrounded by mountains, and except for the channel of the river can only be entered by passes.† It consists of two parallel troughs separated by the Zaskar range both of which drain towards the south-east and away from the Indus.

After its junction with the Spiti the Sutlej becomes a furious torrent dashing over a rocky bed, and forms one continuous rapid from its source to the plains. There are, however, signs of the former existence of a series of lakes along its course: terraces composed of stratified deposits are to be seen in many places, and these are evidences

* *Narrative of a journey from Cawnpore to the Boorendo pass made in* 1821, by Lloyd and Gerard, 1840.

† Atlas sheet No. 65, 1 inch = 4 miles.

that the Sutlej once meandered slowly through Himalayan lakes, as the Jhelum does now through the Wular lake. Many of the feeders of the Sutlej in the hills show signs of having run at higher levels within recent times.

Passage of the Himalaya by the Sutlej.

The Sutlej crosses the great Himalaya at a point where the range bifurcates, and it is difficult to trace a connection between the ranges on either side of it. At Rampur it crosses the Dhauladhar range through a narrow gorge of solid rock. The passage of the Sutlej across the great Himalaya and the Dhauladhar ranges is illustrated in figure 4 of chart XVI (see also chart XVIII). Figures 1 and 2 of chart XIX show the Sutlej escaping through successive Siwalik ranges. It is interesting to observe on chart XIX how effectually these small ranges stopped and deflected the Sutlej below Bilaspur.*

In its course over the plains the Sutlej is supposed to have flowed at one time through the Patiala and Bikanir states and to have joined the Indus in southern Sind: it now bends to the west on leaving the mountains, and joins the Beas. It is believed to have changed its old and straighter course to the sea for its present and less direct one about the end of the tenth century: † the advancing sands of the Rajputana desert have been supposed to be the cause of the change.‡

The fall of the Sutlej from its source to the plains of India is very uniform, and averages on every section of its length about 30 or 35 feet per mile: the height of its bed is 15000 feet near Rakas Tal, 10000 feet near Shipki, 3000 feet at Rampur, 1000 feet at Bilaspur.

The Beas.

The Beas or Beyah (*Sanskrit* Vipasa, the Hyphasis of the Greeks) rises in the Pir Panjal range at the Rohtang pass near the source of the Ravi (chart XXXII): its several affluents combine to pierce the Dhauladhar range at Larji § (chart XVIII). In the 75 miles from its source to Larji, its fall averages 125 feet a mile,|| but after Larji the gradient rapidly decreases, and in the valleys of the outer Himalaya is hardly more than 10 feet a mile.

The upper basin of the Beas encloses the district of Kulu, which for beauty of scenery is the rival of Kashmir.

Six miles from its source the Beas enters the gorge of Koti. "Here the river "plunges into a vast chasm, enclosed on either side by a precipitous barrier of rock and 20 "feet apart and often almost touching. For some 300 yards the Beas races through "this almost subterranean passage, when it again bounds into the sunlight, its exit on "the further side being most strikingly beautiful."¶

South of Larji the Beas passes through another precipitous defile intersecting the Dhauladhar range; below the defile its valley widens out.

Sir Alexander Cunningham estimated the minimum discharge of the Beas at not less than 3000 cubic feet per second.

* Atlas sheet No. 47, 1 inch = 4 miles.

† *A Manual of the Geology of India*, page 450.

‡ *Annual Report of the Board of Scientific Advice for India*, 1905-06.

§ Atlas sheet No. 47.

|| Alexander Cunningham's *Ladak*, page 124.

¶ *Selections from the records of the Government of the Punjab, No.* 10, *Himalayan districts*, by Captain Harcourt.

The Ravi.

The Ravi (*Sanskrit* Iravati, the Hyaraotes of the Greeks), illustrated in chart XXXII, is the smallest of the five rivers of the Punjab : it has its sources in a remarkable mountain knot formed by a conjunction of lesser Himalayan ranges (chart XVIII). The Nag Tibba range appears here to have been forced from the south-west against the Dhauladhar range, and the latter has combined with the Pir Panjal range to form the rock-basin of Bangahal.* The Ravi rises in the basin of Bangahal, and drains the southern slopes of the Pir Panjal and the northern slopes of the Dhauladhar. The basin of Bangahal is sixty miles in circumference. Numerous tributaries of the Ravi flow down its inner walls, many of them with steep gradients ; the Bhadal rises on the north at 16000 feet, and falls 314 feet a mile for 35 miles ; the Nai, which rises in the mountain known as Kali Devi, has a length of 30 miles, and an average fall of 366 feet a mile.†

The height of the bed of the Ravi at the lowest point (Wulas) of the Bangahal basin is about 5000 feet. Gathering together all the water that runs off the inner walls of this extraordinary rock cauldron, the Ravi flows out to the west.‡

The gorge, by which it escapes from Bangahal, may without exaggeration be described as inaccessible : it appears to have been scooped out of solid rock and its sides are perpendicular.

After leaving Bangahal the Ravi flows through the valley and state of Chamba in a north-westerly direction parallel to the Dhauladhar range (chart XVIII). West of the Chamba capital it makes a sudden bend at right angles and cuts its way through the Dhauladhar to the south-west. The defile that it has carved through the range is a few miles north-west of the station of Dalhousie.

The Ravi leaves the Himalaya at Basaoli: the length of its course in the mountains is 130 miles, and its total drop 15000 feet; its fall therefore averages 115 feet a mile.

The Chenab.

The Chenab (*Sanskrit* Asikni, the Acesines of the Greeks) has two chief upper streams, the Chandra and the Bhaga, and the river below their junction is called by their joint name the Chandra Bhaga (chart XXXIII).

The Chandra and the Bhaga rise on opposite sides of the Baralacha pass (16047 feet), the Chandra on the south-east, the Bhaga on the north-west.§ They unite at a place called Tandi, 7500 feet above sea-level. The course of the Bhaga above Tandi is direct and only 60 miles in length : that of the Chandra is in the form of a loop, and is 115 miles long. The fall of the Bhaga is 150 feet a mile, twice that of the Chandra.||

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* The flanks of the ranges are in contact, not the axes.

† Sir Alexander Cunningham's *Ladak.*

‡ Map of Kangra, sheet 2 (1 inch = 2 miles) ; Atlas sheet 46.

§ Atlas sheet 46.

|| General R. Maclagan, R.E., on *The rivers of the Punjab. Proceed., R. G. S.*, Vol. VII, 1885.

"A mile from its source the Bhaga enters the Suraj-dul, a lake about a mile and a "half in circumference, 16000 feet above sea-level, and escaping through this flows for "ten or eleven miles to below Zingzingbar, a barren encamping ground."*

"Leaping from a bed of snow on the south-eastern slopes of the Baralacha, the "Chandra is from its commencement a stream of some size. It passes through a totally "barren land, where there are no signs of life, the solemn mountains clad in eternal snow "lying on its either flank. No villages adorn its banks, no attempts at cultivation, no "signs of human life are to be met with, and nothing greets the eye but the never-ending "and monotonous cliffs, which are lapped by the fierce stream, as it rushes in wild fury "against its banks. Now widening out the Chandra passes the remains of the Shigri "glacier, which some 80 years ago spread across the river and dammed it up, causing "what is known as the cataclysm of the Chandra."†

After their junction at Tandi the Chandra and the Bhaga flow as a joint stream in a north-westerly direction for over 100 miles: throughout this length the valley of the river is the structural trough formed by the great Himalayan and the Pir Panjal ranges (*vide* figure 4 of chart XVI and chart XVIII). Instead of continuing on the same alignment through the valley of Kashmir, the Chenab makes a great bend at Kishtwar, and escapes through the Pir Panjal by a gorge, which it has carved for itself. In the long trough from Tandi to Kishtwar the fall of the river averages 34 feet a mile.

The following description of Kishtwar is taken from Mr. Frederic Drew's well known work, *The Jummoo and Kashmir territories*:‡

"The mountains around are rocky below and have wooded slopes above. The wood "is oak on the eastern hills and deodar and fir on the opposite ridge. The "mountain on the south-west of the plain (of Kishtwar) is a remarkable one; it "is separated from us, as we stand at the western edge of our plateau, by the river valley "(Chenab) which has been cut down to some 1300 feet below us; as we look across, a great "cliff of some 3000 feet in height faces us, from the summit of which the ground slopes "back to the wooded ridge. The most conspicuous and beautiful feature is made by the "drainage from the upper part coming over the cliff in a waterfall of great height. Of this "fall it is impossible to obtain a near and at the same time general view, but by going "some way down the slope, we get a fair sight of it, though at the distance of a mile or "more. The water comes down not in one but many jumps; the aggregate height of the "falls within view is about 2500 feet, and above these are a few hundred feet more, "which can be seen from other points. The first two falls are each of about 500 feet; "these are conspicuous from the town; below them are two or three small ones, making "up six or seven hundred feet more; then there are irregular drops and cascades, partly "hidden by vegetation and by the irregularities of channel, these extending for some "eight hundred feet to the river; thus the two and a half thousand feet are made up."

* *Himalayan districts*, by Captain A. F. P. Harcourt, *vide Selections from the records of the Government of the Punjab*, No. 10.

† *On the Himalayan Valleys, Kulu, Lahaul, and Spiti*, by Captain A. F. P. Harcourt. *Journal, R. G. S.*, Vol. XLI, 1871.

‡ Published 1875.

At Kishtwar the Chenab is joined by the Maru Wardwan river, that has its sources in the glaciers of the Nun Kun peaks.

The Chenab passes the diminishing range of Dhauladhar near Arnas, and leaves the mountains at Akhnur. Akhnur is 180 miles below Kishtwar, and the average fall of the river between the two places is 26 feet a mile.

Above Akhnur "the banks of the Chenab," Mr. Drew writes, "are in places low or "may be cliffs of no more than 100 to 200 feet in height; this is where the river cuts across "one of the flat longitudinal valleys. In other parts opposite the ridges, the river is "bounded by high irregular rocks, which is the range seen in section."*

From the Baralacha pass to Akhnur the length of the Chenab is 400 miles and the total fall is 15500 feet, or 39 feet a mile.

It is worthy of notice that the general course of the Chenab resembles on a smaller scale that of the Sutlej, and that the course of the Ravi resembles on a still smaller scale that of the Chenab. The basins of these three rivers, unlike the symmetrical basins of Nepal, lie obliquely across the mountain ranges.

The Jhelum.†

The valley of Kashmir.

The Jhelum (the Hydaspes of the Greeks), illustrated in chart XXXIII, rises near Virnag at the south-east end of the valley of Kashmir, and flows in a north-westerly direction across a wide alluvial plain, until it enters the Wular lake. Its most distant source is in the lake of Shesha Nag at the head of the Lidar tributary. At its exit from the Wular lake it assumes a south-westerly direction as far as Baramula, where it escapes from Kashmir through a gorge in the Pir Panjal range. ‡

The upper basin of the Jhelum forms part of the trough between the great Himalaya and the Pir Panjal ranges, and is known as the valley of Kashmir. This famous valley is of oval shape, its long diameter lying parallel to the general direction of the ranges. From crest to crest the transverse ridges on the south-east and north-west of the basin are about 120 miles apart, and from the crest of the Pir Panjal range to that of the great Himalaya the distance is 75 miles: the flat alluvial bottom of the basin measures 90 miles from south-east to north-west, and 25 miles from south-west to north-east. On the north-east side peaks of the great Himalaya rise above 17000 feet: on the south-west the loftiest peaks of the Pir Panjal exceed 15000 feet. Those of the two transverse ridges attain to 13000 feet. The height of the alluvium of the valley varies from 5200 to 6000 feet.

Through the alluvial flats of Kashmir the course of the Jhelum is navigable and is the chief artery of traffic: the fall averages a little over 3 feet a mile, and the usual rate of the current is about a mile and a half an hour. At Baramula where its course

* *Jummoo and Kashmir territories*, by Frederic Drew, 1875.

† The Sanskrit *Vedesta*, sometimes known in modern times as the *Behat*.

‡ Map of Kashmir, 1 inch = 2 miles; Atlas sheet 28, 1 inch = 4 miles.

through the open valley terminates, the river rushes through a narrow chasm in the rocks and entirely changes from a placid stream to a raging torrent.*

The alluvial deposits filling up the basin of Kashmir were held by the earlier geologists to have been formed from the waste of the surrounding mountains, and to have been laid down at the bottom of a great lake. It has been stated that these deposits once covered the whole valley to a height of 1000 feet above its present level, and that the greater portion has been carried away by the Jhelum to the plains of the Punjab. The Wular lake which now measures 10 miles in length and 5 in breadth, was regarded by Montgomerie as a last relic of the great expanse of water which once covered all Kashmir. But this idea of a great prehistoric lake has been abandoned by Mr. R. D. Oldham. Mr. Oldham studied the *Karewas* and the present lakes of the Kashmir valley in 1903, and came to the conclusions that the *Karewas* are of fluviatile and not of lacustrine origin, and that there was never at any time a materially larger lake than at the present day.†

" The country of Kashmir," writes Mr. Frederic Drew,‡ " has justly a reputation " for something distinctive, if not unique, in its character. Its position and form together " are such, that there is no parallel to it in the whole of the Himalaya. It is a " plain embedded among the mountains, a wide vale enclosed by mountain ranges, lying " at such a height above the sea as on the one hand to be of a climate entirely different " from that of India, being saved from the heat that parches its plains, and on the other " hand to be free from the severity of cold that visits the more lofty plateaux or wide " valleys."

When Mr. Drew described Kashmir as unique, he had in mind the excellence of its climate : from a geographical or a geological point of view the Kashmir valley is typical of the Himalaya, the Nepal valley, the plains of Dingri, and the plateaux of Tibet being other examples, though at different stages of development.

Passage across the Pir Panjal.

The Jhelum enters the Pir Panjal range near Baramula (5040 feet) in a direction approximately perpendicular to the strike of the mountains and continues on a straight course for 20 miles to Uri.

The defile below Baramula, called by the Kashmiris Basmagul, is 7000 feet in depth, and has almost perpendicular sides In places it is but 70 feet across, and its bottom is wholly occupied by the river.§

At Uri the river changes its course and follows the direction of the range to Muzaffarabad (2470 feet). From Baramula to Muzaffarabad the distance is 80 miles and the fall 2600 feet or 33 feet a mile.

At Muzaffarabad the Jhelum joins the Kishanganga and bending to the south follows the course of its affluent. The strike of the rocks changes at the very point

* See synoptical volume VII, Great Trigonometrical Survey of India.

† *Records, Geological Survey of India*, Vol. XXXII, p. 152.

‡ *The Jummoo and Kashmir territories*, 1875.

§ *On the Trigonometrical Survey and physical configuration of the valley of Kashmir*, by W. H. Purdon. *Journal, R. G. S.*, Vol. XXXI, 1861.

where the Jhelum alters its direction and may be the cause of the latter's bend.* From Muzaffarabad to the plains the fall of the Jhelum is 21 feet a mile.

The Kishanganga.

The Kishanganga rises in the mountains west of Dras and south of the Deosai plateau. It flows through the districts of Tilail, Gurais and Shardi, and skirts the northern rim of the Kashmir basin. After following the strike of the ranges it makes a knee-bend at Shardi, similar and parallel to the knee-bends of the Indus at Bunji, of the Jhelum at Wular, of the Chenab at Kishtwar and of the Ravi in Chamba.

Colonel Montgomerie, who superintended the survey of Kashmir from 1854 to 1863, described the valley of the Kishanganga as being throughout very precipitous, and for the greater part little better than a chasm in the mountains. Its basin is peculiarly narrow and elongated, being in places only 17 miles wide from water-parting to water-parting.

The Kunhar tributary of the Jhelum flows between the Kishanganga and Indus rivers and through the district of Khagan; it joins the parent stream a few miles below the great bend at Muzaffarabad.

The Zoji pass.

The Zoji pass over the Great Himalayan range forms a notch in the rim of the Jhelum's basin: this pass is 500 yards broad and 2 miles long, and its surface is so flat that a pedestrian cannot tell where the actual water-parting is. The ascent from Kashmir to the top of the Zoji is steep, the descent on the northern side is gentle. The height of the pass is 11300 feet; on each of its flanks the crest of the range rises to 13000 feet, and then by slow degrees to peaks of 19000 feet. The Zoji was probably cut by an extinct river or glacier during the growth of the Great Himalaya.†

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* *Memoirs, Geological Survey of India*, Vol. XXII, 1883. *The Geology of the Kashmir and Chamba territories, and the British District of Khagán*, by R. Lydekker.

† *Records, Geological Survey of India*, Vol. XXXI, 1904. *Note on the glaciation and history of the Sind Valley, Kashmir*, by R. D. Oldham.

26

THE INDUS.

Intersections of the Ladak range by the Indus.

The Indus, or Sind (chart XXXIV), rises in the trough between the Kailas and Ladak ranges, and for its first 180 miles flows in a north-westerly direction along the inner flank of the Ladak range. It then forsakes the trough, and bending at right angles cuts through the Ladak range near Thangra. Having pierced the barrier it resumes its north-westerly direction, and this it maintains along the outer flank of the Ladak range for over 300 miles. Near Skardo (8900 feet) it cuts again through the Ladak range, and having crossed back to its original trough, pursues the same north-westerly direction.* A hundred miles below Skardo it makes its third bend; and pierces the Ladak range at Bunji. From Bunji it rushes towards the peak of Nanga Parbat, but is deflected to the west near the foot of the mountain, and after a tortuous passage across the Himalayan ranges it emerges on the plains of the Punjab at Attock.†

We have read in preceding pages of this paper of many instances of rivers piercing mountain ranges, but the Indus furnishes a unique example of a river, that passes backwards and forwards across the same range three times.

The gradient of the Indus.

From the source of the Indus to Pitak opposite Leh the distance is 400 miles, and the fall of the river 6000 feet or 15 feet a mile. The whole length of the mountain course of the Indus from its source to Attock is 1100 miles, and the whole fall is 16000 feet or 15 feet a mile. Over a considerable length of its course in Tibet the fall is hardly more than 3 feet a mile; between Skardo and Bunji the fall averages 21 feet a mile. The equable and comparatively gentle fall of the Indus, as it crosses the Himalaya, is very remarkable: it is due to the low level to which it has cut its bed on the plateau of Tibet. When the Brahmaputra leaves Tibet the height of its bed is still above 8000 feet, but the height of the Indus at Bunji when it turns to quit the plateau is only 4600 feet.

The fact that the Indus has cut down its bed in Tibet to a greater extent than the Brahmaputra has promoted the development of its Tibetan tributaries.

"At Ohind," wrote Sir A. Cunningham, 15 miles above Attock, I found the "current of the Indus much more rapid than that of any other river of the Punjab. From "its source to Ranak the Indus is a broad and fordable stream, rolling its sluggish waters "through open grassy plains. Its general width is about 250 feet. From Ranak to "the junction of the Zaskar river the stream is a brawling rapid from 100 to 150 feet "broad, and thence to the confluence of the Shyok it is a furious torrent raving from "side to side of a narrow ravine."‡

* The gorge near Skardo where the Indus breaks across the Ladak range is said to run between precipices 14000 feet sheer: see article *Indian, Imperial Gazetteer, first edition.*

† Map of Turkistan, 1 inch=16 miles. Punjab map, sheets 5 and 6 (1 inch = 8 miles), atlas sheets 27a S. E., and 44, 45, 46 and 64.

‡ *Ladak and surrounding countries*, page 89.

General Maclagan estimated the fall of the Indus as follows: "Twenty-four feet "per mile from the source to Skardo, 600 miles. Seventeen feet per mile from Skardo to "Attock, 440 miles. Fifty inches per mile from Attock to Kalabagh, 110 miles. Twelve "inches per mile from Kalabagh to Mithan Kot, 370 miles. Six inches per mile from "Mithan Kot to the sea, 470 miles."*

It is so seldom that a truly vertical drop has been discovered on the course of a main Himalayan river, that a fall of the Indus is perhaps worthy of mention. It was observed by Sir Martin Conway north of Kashmir. "The Indus itself," he wrote, "plunges in a single white wave over a drop of about twenty feet, and then races down "a rapid."†

Exploration of the Indus.

The little that is known of the course of the Indus between Bunji and Attock has been derived from the observations of an explorer in 1876. This man, described in the reports of the Indian Survey as the Mullah, made a rough survey of the course of the river for a length of 220 miles above Attock.

In the 220 miles that intervene between Bunji and Attock, the river descends from a height of 4600 feet to one of 1200 feet. Its way winds tortuously through great mountain ranges and its valley is in many places but a narrow deep-cut gorge: as a rule there is more open space and culturable land in the lateral valleys nestling between the spurs than on the trunk stream.‡

On the former and present level of the bed of the Indus.

"The Indus valley," wrote Sir Martin Conway, "in the Bunji reach, is to be pictured "as broad and flat-bottomed. Its western side is a mighty "wall of rock. On the east it is bordered by steep slopes. "The slopes and the wall must meet not less than 500 "feet, and probably as much as 2000 feet below the level of the surface of the débris "accumulations, which fill the valley. By what processes were these vast débris "accumulations brought together?"§

"By far the deepest of all the river valleys," wrote Mr. Lydekker, "is that of "the Indus below Bunji in Gilgit. Between that place and the Darel district, which "has hitherto only been traversed by native explorers, the writer is informed by Lieu-"tenant-Colonel H. C. B. Tanner of the Survey of India that the river flows in a narrow "gorge, bordered by vast precipices ranging up to 20000 feet in height, at a level of a "little over 3000 feet; thus making the river gorge nearly 17000 feet in depth. That "a great part of this tremendous gorge has been cut by the river itself is proved by the "occurrence of river gravels and honey-combed rock surfaces many hundreds of feet "above the present river-level."||

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* *Proceedings, Royal Geographical Society*, Vol. VII, 1885.

† *Climbing and exploration in the Karakoram Himalayas*, page 589.

‡ *General Report, Survey of India*, 1876-77.

§ *Climbing and exploration in the Karakoram Himalayas.*

|| *Memoirs, Geological Survey of India*, Vol. XXII, 1883.

Many observers have noticed that the Indus once flowed at a level considerably higher than its present bed. The following extract is from a report by Adolphe de Schlagintweit written in 1856 :—

"In the valley of the Indus near Skardo, in the valley of Astor near the place "where the Indus enters the Himalaya, I on several occasions observed gravel and "sand beds evidently deposited by these rivers, and ancient marks produced by the "large streams on the rocks, at elevations of 3000 and 4000 feet above the present "level of the rivers. We have many proofs independent of each other to show the great "depth, to which all the valleys of the rivers, tributary to the Sutlej and Indus, have "been excavated."

"The decrease of glaciers as observed by us must be due to some general change "in the climate of the surrounding country, and I think that we have numerous obser- "vations to show that this change of climate is due in a great measure to the great "excavation of the Tibetan and Himalayan valleys by the action of the rivers."

"Many of the valleys of western Tibet exhibit ancient water marks at 3000 and "4000 feet above the present bed of the river. The sides of these rocky valleys, thus "gradually excavated, are now heated under the influence of the sun to a much greater "extent than was the case formerly; the warm air, thus produced, ascends the valleys, "and tends to melt the ice of the glaciers near the origin of the valleys, to a greater "extent, than was the case before the excavation of the valleys had taken place."*

Referring to the same subject Colonel Godwin-Austen wrote: "The height of "the upper lacustrine deposit at Kuardo is quite 4000 feet above the present river, and "this deposit also rests on the rock of Skardo in the town. Once this Skardo basin "contained a vast lake with swampy grassy margins, long subsequent to the time when "the higher deposits were settling down in the first deep lake."†

Sir Alexander Cunningham wrote: "The bed of the Indus, like that of all the "other rivers, has once been crowded with a series of lakes."‡

The principal tributaries of the Indus.

We have so far been treating of the Indus itself, and we have now to refer to its Himalayan tributaries; of these the following are the most important :—

(i) the Singhgi, (ii) the Zaskar, (iii) the Dras, (iv) the Shyok, (v) the Shigar, (vi) the Gilgit and (vii) the Kabul.

The areas of the catchment basins drained by the seven tributaries may be approximately estimated as follows :—

Kabul	river	35000	square miles.
Shyok	,,	13000	,,
Gilgit	,,	10000	,,
Zaskar	,,	10000	,,
Singhgie	,,	7000	,,
Dras	,,	5000	,,
Shigar	,,	5000	,,

* *Journal, Asiatic Society of Bengal*, Vol. XXVI, 1857.

† *Journal, Royal Geographical Society*, Vol. XXXIV, 1864.

‡ *Ladak and surrounding countries.*

It will be noticed that four of the tributaries have larger mountain basins than the Ganges, and that the Kabul river has a larger basin than seventeen out of the nineteen rivers of table xxx.

Colonel Montgomerie compared the tributaries of the Indus with those of the Brahmaputra as follows: * "Judging from my knowledge of these rivers I should "say they were not equal to the six tributaries of the Brahmaputra above Lhasa "as described by the Pandit. But supposing that they are equal and that the sizes "of rivers are somewhat in proportion to their lengths of course, *i.e.*, that they "would drain the same area, I conclude that the Brahmaputra below the junction "of the Lhasa river is at least equal to the Indus at Attock. The latter probably "drains a country which receives very much less moisture than the Lhasa "territory."

One of the native explorers expressed astonishment to Montgomerie, that the Brahmaputra in Tibet became no broader, after it had received its largest tributaries. Montgomerie referring to this peculiarity wrote that it is "quite in accordance with "what is known of the upper course of the river Indus. The Indus receives the Zaskar, "a river nearly as large as itself, below Leh, and yet the increase in the breadth of the "main stream is hardly perceptible to an ordinary observer. The same thing happens "at its junction with the Dras river, and again it is still more remarkable at the point "where the Shyok river joins the Indus, both great streams with but little difference "in volume, yet the combined stream appeared to me almost narrower than either of "them separately: the increased volume of water having simply made the stream "deeper."

The Singhgi.

The Singhgi is the name given to the eastern branch of the Indus, which drains the slopes of Aling Kangri peak. The existence of this eastern branch was doubted at one time by geographers, but it was indicated by Henry Strachey from native information on his map of Ladak in 1853. In 1867 a route survey by the Pandit Nain Singh proved that the eastern branch was in truth the main stream of the Indus. The Pandit named this river the Singhgi Chu or Singhgi Kamba.†

The branch of the Indus, known as the Garjung or Gartang, and which flows by Gartok, and which is generally accepted as the source of the great river, is smaller than the Singhgi.‡

The Zaskar.

The Zaskar rises between the Indus and the great Himalaya range; at its commencement it flows towards the range, as though it were going to pierce it, but it sweeps round through two right angles, and turning away from the great Himalaya, it pierces the Zaskar range, in which it had its source, and joins the Indus below Leh.

From its source to Padam the distance is 140 miles, and the fall 4000 feet, or 28 feet per mile. At Padam (12000 feet) the Zaskar makes its second bend, and adopts

* In his reference to *six* tributaries Montgomerie was omitting the Singhgi.

† *Report of the Trans-Himalayan Explorations during* 1867, by Captain Montgomerie.

‡ Northern Frontier sheet, 14 N.W., 1 inch = 4 miles.

its final direction towards the Indus: from Padam to the Indus the length of the river is 90 miles, and the fall 2000 feet or 22 feet per mile. According to Henry Strachey the main supply of water in the upper part of the Ladak Indus is derived from the Zaskar river: this river has its sources in Himalayan glaciers, whilst the other affluents, though longer, rise in drier climates.

The Dras.

The Dras river drains the plains of Deosai by means of its two tributaries, the Shingo and southern Shigar:* it also drains the mountain slopes north of the Zoji pass. Its great tributary is the Suru, which like the Zaskar starts on a course towards the great Himalaya, but eventually bends completely round and flows away from the range.

The Suru makes an extraordinary loop at the base of the Nun Kun peaks.† Dr. Neve writes that the Suru river, having cut a deep and narrow gorge at the bend, has become roofed in by boulders and débris for 300 yards.

The Shyok.

The Shyok rises behind the Karakoram range, and after piercing the range joins the Indus near Kiris: the great bay, which is to be seen in the water-parting line of the Indus in rear of the main range on chart XXXV, is drained by the river Shyok. The Trans-Karakoram basin of the Shyok contains the well-known plains of Dapsang. The passage of the Shyok across the Karakoram range is indicated in the longitudinal section of chart XX.‡

From its sources near the Karakoram pass § to its junction with the Indus, the length of the Shyok is 400 miles, and the total fall is 11000 feet or 27 feet a mile.

"The general character of the Shyok," wrote Sir A. Cunningham, "is exactly "the reverse of that of the Indus. Its upper course is rushing and turbulent, down "a narrow glen, but its middle course is either broad or divided into numerous "channels in an open valley: and in these places where the waters are much scattered, "the river is generally fordable, although not without difficulty. Between Tertse and "Unmaru there are seven distinct branches, of which three are between 300 and 400 "feet in width and the others much smaller, with an average depth of two feet."

"At the Turtuk bridge the river narrows to 70 feet, and in the lower part of its "course, the Shyok is generally a furious rapid confined between precipitous cliffs."||

At 10000 feet elevation the bed of the Shyok is four miles wide.¶

The principal tributary of the Shyok is the Nubra which has its source in a large glacier, the Saichar; this glacier lies across the Karakoram range, and appears to have cut back to a point 35 miles behind the crest-line of the range. The Nubra rises and flows amid great mountains; on the portion of the Karakoram range, which is situated between the Nubra and the Shyok, the principal peaks vary from 24000 to upwards of 25000 feet in height.

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* Not to be confused with the northern Shigar river, which joins the Indus near Skardo. Map of Turkistan and Punjab Map.

† Ser and Mer of table VI.

‡ Atlas sheets 44 and 45.

§ This pass is not on the main Karakoram range, but on the parallel ridge behind.

|| *Ladak and surrounding countries.*

¶ Dr. Hunter Workman and Mrs. Bullock Workman: *In the ice-world of Himalaya.*

The valley of the Nubra consists of a flat plain, a few miles broad, bounded on each side by almost vertical cliffs which rise 4000 or 5000 feet above the river.*

"From Tsati to Changlung," write Dr. Hunter Workman and Mrs. Bullock Workman, "some forty miles, the Nubra valley is from two to three miles wide, and presents "some features not seen everywhere in Himalayan valleys. The valley bottom is "composed of alluvium, sand and stones, over which the river flows in a broad bed "with many channels and arms, which leave the main stream at various points, and "soon join it again enclosing in their course numerous islands. The river is fed by many "tributary streams."†

The northern Shigar.

The northern Shigar river drains the southern slopes of K^2 and collects its waters from the Biafo, Baltoro and Chogo Lungma glaciers.

The Gilgit.

The Gilgit river has two principal branches, the Gilgit and the Hunza: both branches have pierced the Karakoram range, and both now drain considerable areas behind it.‡ The Gilgit is the more western branch, and has its sources near the Darkot and Baroghil passes of the Hindu Kush.

The following extract is from an account of the Gilgit valley by Sir Martin Conway:—"This accumulation of débris fills up the valley to a depth of probably "from 500 to 1000 feet or more. The Gilgit river flows in a gorge like a canyon, not "so much cut through as built up by this accumulation."

"Mud avalanches appear to be annually discharged by all the gullies, which "reach up to the snow region, and traverse the barren levels beneath. Rapid ærial "denudation, the extraordinary activity of which has been observed by all travellers "in the desert belt of the world, annually provides the materials for these discharges."§

In rear of the Kailas and Karakoram ranges the Hunza valley is broad and open, but it becomes a defile with precipitous sides as the river passes through the ranges. The Hunza river pierces the Kailas range within 9 miles of Rakaposhi, the highest point of the range.

"The Hunza valley," we quote again from Sir Martin Conway, "in its present "condition shows the intermediate stage through which the Indus valley has passed. "The Hunza river flows down a gorge between alluvial cliffs. The ancient alluvial "cliffs of the Indus practically exist no more. It is only here and there at high altitudes "that a fragment of them remains."

"The fact seems to have been that all the valleys of this region were at one time in "the condition exemplified by the Pamirs, filled to a depth of from one to two thousand "feet with mud avalanche débris. In the present geological period this deposit has "been largely washed out again, but the depth of the existing valleys is not much below "that of the old ones in which the deposit was laid."||

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* *Great Trigonometrical Survey of India, Synoptical volume VII.*

† *In the ice-world of Himalaya.*

‡ Northern Trans-frontier sheets, Nos. 2 and 3, 1 inch = 8 miles: also 3 N. E., 3 N. W., 1 inch = 4 miles.

§ *Geographical Journal*, Vol. II, 1893.

|| *Climbing and Exploration in the Karakoram Himalayas.*

The Kabul.

The Kabul river takes its name from the Afghan capital town, near which one of its branches flows. Thirty-five miles east of Kabul it receives the Panjshir affluent, draining a great length of trough between the north and south Hindu Kush ranges.* Subsequently the Kabul receives from the north-east the rivers of Kafiristan, of Chitral and of Swat, which flow parallel to the Indus (chart XXXIV). The most important of its tributaries is the Kunar, which has been graphically described in Sir Thomas Holdich's *Indian Borderland*: this river, known higher up as the Mastuj, rises in the same Hindu Kush trough as the Panjshir and pierces the Southern Hindu Kush range in Chitral.

Floods.

The Indus, like the other rivers of the Punjab Himalaya, is subject to sudden and extraordinary floods: these are due not to excessive rainfall but to the damming of the river by huge landslips.†

In December 1840, a side of the hill known as the Hatu Pir fell into the defile of the Indus at the base of Nanga Parbat, and formed a dam 1000 feet high. An immense lake was created behind the dam, the water in which became at one place 900 feet deep; at Bunji the water rose to the level of the fort, 300 feet above the bed of the river; the lake became nearly 40 miles long and reached almost to Gilgit town. For six months the waters were held back by the débris of the fallen mountain, till they rose to the level of the top of the dam. The dam then burst, and the lake emptied in one day, the immense volume of water rushing down to Attock.‡

* North-West Trans-frontier sheet 27, 1 inch = 8 miles: Northern Trans-frontier sheets 2 and 3.

† These landslips occur more frequently in the bare mountains of the Punjab than in the more wooded parts of the Himalaya, but all Himalayan rivers are liable at times to be dammed by slips. In 1893 a tributary of the Ganges was dammed at Gohna by the fall across its course of a mountain side.

‡ This account is given on the authority of Colonel Montgomerie. Mr. Fraser in his *Marches of Hindustan* attributes the cataclysm of the Indus in 1841 to the damming of the river by a glacier.

27

THE HIMALAYAN RIVERS: SUMMARY.

On the direction of river-flow in the structural troughs of the Himalaya.

Rivers flowing in troughs of the Punjab Himalaya pursue as a rule north-westerly courses; the Sutlej, the Beas, the Ravi, the Chenab, the Jhelum, the Kishanganga, the Zaskar and the Indus all follow similar directions in the mountains. In the Nepal and Assam Himalaya opposite conditions obtain. The Kali, the Karnali, the Arun, the Sun Kosi, the Narayani, the Lopra, the Onchu and the Brahmaputra all assume easterly courses in the mountains.

In the Punjab Himalaya the only important exception to the rule is the Spiti: in the Nepal Himalaya there is the exception of the Birehi, the principal tributary of the Karnali.

In the Himalaya of Kumaun, which intervene between the Punjab and Nepal, the direction of flow is less regular: in the trough behind the great Himalayan range, the Bhagirathi flows to the north-west, and in the trough behind the lesser Himalaya the Alaknanda does the same, but their courses in general do not altogether conform to the Punjab type of river.

It may be that the rivers which flow to the north-west have had their directions determined by the bifurcating ranges of the great Himalaya: the Chenab, the Ravi, the Kishanganga and the Jhelum all rise in the acute angles formed between the great Himalaya and its offshoots. The Sutlej, however, has cut its course across both the great range and its branches, and has clearly not been deflected by the latter. The evidence furnished by the direction of river-flow perhaps warrants the inference that the heights of the Kumaun Himalaya and of the Manasarowar basin have been increased in recent times;* and that the uplift of this central portion of the mountains has helped to determine the direction of flow in the troughs on either side.

When once the Himalayan rivers have reached the plains, those that belong to the system of the Indus flow directly away from the mountains, but those that feed the Ganges turn to the south-east and tend to flow parallel to the Himalaya.

On the gradients of river beds.

The gradient of the bed of a Himalayan river varies so widely at different points of its course, that it is doubtful whether the calculation of the average drop over the whole length affords information of any value.

* The relative positions of the peaks of Nanda Devi, Gurla Mandhata, Kamet and Kailas convey the idea that thrusts from the directions of Nepal and the Punjab have in recent times given an additional elevation to the already high mountains of Kumaun along a transverse zone.

When a river descends from a single mountain range, its gradient tends to decrease gradually from its source to its mouth; * in its first stage it is torrential, in its last sluggish. But when a river has to pierce several parallel ranges, as in the Himalaya, the case is different; its stream becomes then confined, in the intervals between its drops, to comparatively level structural troughs lying between two ranges. In these troughs the velocity of the water is checked by the decrease of gradient, and the river, depositing its load of gravel and silt, forms for itself a flat and open bed.

A river confined to a trough will flow for miles with a fall of 5 or 10 or 20 feet a mile; it will then cut a gorge through one of its barrier ranges, and descend to the next trough with a fall of 100 or 200 feet a mile.

The floors of the several Himalayan troughs lie at different heights above sea-level: it is not possible to state exactly the height of any trough, because however level it might have been originally it has now been cut down and given a gradient by the river flowing through it. The heights shown in the following table must therefore be regarded as rough averages.

TABLE XXXI.—Heights of floors of troughs.

Trough.	Region.	Average height in feet of floor above sea-level.
Between the Kailas and Ladak ranges	Brahmaputra	12000
	Manasarowar	15000
Between the Ladak and Great Himalayan ranges	Arun	13000
Between the Great and Lesser Himalayan ranges	Kashmir	5300
	Sun Kosi	3000
	Pindar	3000
Between the Lesser Himalayan and the Siwalik range	Ramganga	1500
	Dehra Dun	2000
Level of plains outside the Siwalik range	Opposite Nepal	600
	Opposite Kumaun	850
	Opposite Punjab	900

The Arun in its high level trough north of the great Himalayan range flows for 70 miles with a fall of 15 feet a mile, but when it forsakes its trough and pierces the great Himalaya, it drops 10000 feet in 150 miles, or 67 feet per mile.

The Arun is not stopped or deflected by the lesser Himalaya, but many rivers, of which the Sun Kosi is one, after rapid descents from the great Himalayan glaciers, flow in the trough below for long distances and with greatly diminished gradients.

* This rule is modified, when the rocks, over which the river passes, possess different powers of resistance to its wear.

The following table gives a few numerical estimates of average gradients; it is not possible as yet to draw any sections along actual river beds, as sufficient numbers of heights are not available.

TABLE XXXII.

Position of source.*	River.	Height at its passage of great Himalayan axis.	Length in the mountains.	Average fall per mile.	Variations of fall.
		Feet.	Miles.	Feet.	
North of Ladak range.	Indus.	4000	1100	15	10 feet per mile near Gartok; nowhere as much as 25 feet per mile except for very short distances.
	Sutlej.	9000	560	30	In Tibet 34 feet per mile; in the Himalaya 39 feet; below Bilaspur 5 feet.
South of Ladak range, but north of the great Himalayan range.	Alaknanda.	6000	200	75	160 feet a mile at the passage of the great Himalaya; from Srinagar to Hardwar 14 feet a mile.
	Kali.	9000	150	100	This river seems to pursue a straight course across the mountains without deviating into longitudinal troughs.
In the great Himalaya.	Bhotia Kosi.	5000	unknown	unknown	This river appears to drop 13000 feet in its first 30 miles—over 400 feet a mile. Though this estimate may be wrong the fall is certainly immense.
	Jhelum.	does not cross	400	28	200 feet a mile near its source; 3 feet a mile for 120 miles in Kashmir; 35 feet a mile below Baramula.
	Chenab.	does not cross	380	40	65 feet a mile near its source; 22 feet a mile from Tandi to Kishtwar: 100 feet a mile at passage of Pir Panjal; 20 feet a mile above Akhnur.
In the lesser Himalaya.	Beas.	does not cross	250	48	125 feet a mile from its source to Larji: 11 feet a mile below Mandi.
	Ravi	does not cross	130	115	200 feet a mile near its source; seldom less than 50 feet a mile anywhere.

Numerical estimates of gradients are always liable to be too steep: the numberless sinuosities of a river flowing through mountains cannot be shown on a map, and the length of the stream is always measured too small.

The following are the various lengths obtained for the river Ganges from Badrinath to Hardwar as measured from different maps:—

	Miles.
from the map of India on the scale of 1 inch = 32 miles . . .	127
from the index map of Kumaun on the scale of 1 inch = 12 miles .	133
from the atlas of India on the scale of 1 inch = 4 miles . . .	143
from Kumaun and Garhwal survey on the scale of 1 inch = 1 mile .	155

* The sources of all these rivers are above 16000 feet. It is not possible to state the height of the source of a river rising in mountains except approximately. The lower end of the principal glacier marks the point where a stream of water is first visible, but this is not the source of the river. The snow, that falls on the highest peaks, may eventually find its way into the glacier and thence into the river.

Chart XXXVII has been drawn to show that the further back a river rises in the Himalaya or Tibet the less likely it is to have a steep average gradient. The fall of a river like the Brahmaputra rising in Tibet must tend to be less than that of one like the Ravi, which rises in glaciers of the lesser Himalaya.

It cannot, however, be laid down that the gradients of rivers depend only or even mainly upon the positions of their sources, for much depends upon the subsequent straightness of course. A river, for instance, like the Kali, that cuts straight across the hills from its source to its exit, tends to develop a steeper average gradient than one like the Jhelum, which meanders through the trough of Kashmir.

Positions of the sources of the principal Himalayan rivers.

The following rivers rise in the lesser Himalayan ranges :*—

The Ramganga (chart XXV),
Baghmati (chart XXVII),
Beas (chart XXXII),
Ravi (chart XXXII).

The following rise in the great Himalayan range (chart XXXVII) :—

The Mandakini (chart XXIV),
Seti (chart XXVI),
Indrawati (chart XXVIII),
Madi (chart XXVII),
Dudh Kosi (chart XXVIII),
Jumna (chart XXIV),
Tons (chart XXIV),
Jhelum (chart XXXIII),
Kishanganga (chart XXXIII),
Chenab (chart XXXIII).

The following rise behind the great Himalayan range :—

Bhotia Kosi (chart XXVIII),
Tambar Kosi (chart XXVIII).
Tista (chart XXVIII).

The following rise in the Zaskar range :—

Kali (chart XXV),
Alaknanda (chart XXIV),
Bhagirathi† (chart XXIV),
Spiti (chart XXXI).

The following rise in the Ladak range :—

Arun (chart XXVIII),
Kali Gandak (chart XXVII),

* The position of the source of the Rapti (chart XXVI) is uncertain.

† In diagram 4 of chart XXXVII the Bhagirathi has been shown as rising in the trough behind the great Himalaya. This is correct, but it rises in the Zaskar range and not in the Ladak.

Karnali (chart XXVI),
Birehi (chart XXVI),
Raidak (chart XXIX),
Manas (chart XXIX).

The following rises in the Kailas range :—

Sutlej (chart XXXI).

Affluents of the following rise in Tibet north of the Kailas range :—

Indus (chart XXXIV),
Brahmaputra (chart XXX).

The rivers that rise in Tibet show great differences in the depths to which they have cut down their channels. At its escape from Tibet the Indus is 1000 feet lower than the Karnali, 3400 feet lower than the Brahmaputra, and 5400 feet lower than the Sutlej.

Variations in river-gradients.

It has been suggested that the increase in gradient during a river's passage of a range has been caused by the gradual rise of the range across the course of the river,—that the river has been unable to wear away the range as rapidly as the latter has grown.

The larger rivers, it has been stated,* are usually observed, within ten miles of the line of the great peaks, to be flowing at an elevation of little more than 4000 feet, but "on crossing that line the acclivity suddenly and rapidly increases, and the river "beds are found in a few miles to be at an altitude of 9000 or 10000 feet. Above "this the gradient falls again, and in the Tibetan region the average slope does not "seem to be more than a few feet in each mile of channel."

"This sudden rise in the river beds as they cross the line of highest peaks seems "to show that this has been a region of greater and more rapid upheaval than those "to the north or south."

We do not think that any such deduction is admissible: a river passing from a high level trough to one of low level must necessarily flow on a steeper gradient during the descent than when confined to either trough, and the variation in gradient does not seem to us to furnish evidence as to the rate of upheaval.

It may indeed be questioned whether the gradient of a Himalayan river ever increases, as it passes the *axis* of the great range : the Kali Gandak for instance rising in the Ladak range descends 3180 feet in its first 12 miles, from 15080 to 11900, or 265 feet a mile : in the next 22 miles it is in a trough and falls 2950 feet, or 134 feet a mile : it then commences its drop to the outer trough and descends 6900 feet in 38 miles or 181 feet a mile. If the barometric observations of the explorer are reliable, the river commences its increased fall of 181 feet a mile, not at crossing the great Himalayan *axis*, but at its *entry* into the great range. We believe that this is the case also with

* *Journal, Royal Geographical Society*, Vol. XXI, 1851.
Encyclopædia Britannica, Vol. XI.
A Manual of the Geology of India, 2nd Edition, page 462.

the Alaknanda and the Arun. The great range is 50 miles broad, and the rivers increase their gradient, as they pass not its axis but its northern edge.

Mountain slopes in the Himalaya.

Dr. Hooker found that the peak of Jano was 5 miles distant and rose 13932 feet above the village near which he was encamped. "This," he wrote, "is one of the most sudden slopes in this part "of the Himalaya, the angle between the top of Jano and Kambachen being 2786 "feet per mile, or 1 in 1·8. The slope from the top of Mont Blanc to the Chamouni "valley is 2464 feet per mile, or 1 in 2·1. That from Mont Rosa top to Macugnaga "greatly exceeds either."*

In the basin of the Dhauli (Alaknanda) there is in one place a drop of 7000 feet in one mile. In the basin of the Kali an instance is known of a fall of 14000 feet in $1\frac{3}{4}$ miles, or 8000 feet a mile.† On the north side of the Karakoram from the peak of K^2 to the bed of the Oprang tributary of the Yarkand river the drop is over 3000 feet a mile for 5 miles. From the peak of Haramosh on the Kailas range to the bed of the Indus the drop averages 2350 feet a mile for 8 miles.

The large angles of slope that are to be found everywhere in the great Himalaya are not met with in the outer and lower ranges: perpendicular drops of a few feet are common everywhere, but it is seldom in the lesser Himalaya that we meet with a difference of height of 1500 feet occurring within a horizontal distance of 1 mile.

* *Himalayan Journals*, Vol. I, page 258, footnote.

† This fall takes place between Hasaling peak and the bed of the Gori, *vide General Report, Survey of India*, 1874-75.

28

THE RIVER-GORGES OF THE HIMALAYA.

There is hardly a mountain range in Asia that has not been cut across by a river. A river which has been flowing for miles along an open trough between two parallel ranges will suddenly bend and piercing one of the ranges will escape through a precipitous gorge.*

The lengths and depths and forms of the stupendous gorges, through which the rivers of Asia pass the mountain ranges, have excited the wonder of all travellers who have seen them: the extraordinary narrowness of the defiles, the perpendicularity of their walls and the immense difference of altitude between the beds of the rivers and the peaks towering immediately above them have given to these wonderful chasms an absorbing geographical interest.

In many instances a range is found to possess the same form and character on the two sides of a river-gorge intersecting it, but in others it appears to undergo a complete change. No difference can be observed, for example, in the shape or height or alignment of the Pir Panjal range on the two sides of the gorge of the Jhelum, and the great Himalayan range itself does not change its form at the passage of the Arun Kosi. But at its intersection by the Sutlej the change in the great range is so complete that it is difficult to trace a connection between the mountains on either side of the gorge.

Many controversies have arisen over the origin of the great river-gorges. A century ago the explanation generally accepted was that earthquakes or other convulsions had produced long fractures through the mountains, and that the rivers had found their way along the cracks; but subsequent examinations of rocks below the beds of gorges so frequently showed no signs of fractures, that it is now generally acknowledged that the gorges have been slowly carved by the rivers themselves during the course of ages.

Though, however, the defiles of many rivers are unconnected with transverse fractures, yet a certain few, among which the Alaknanda is one, are now known to follow the lines of geological faults; even in these cases however the gorges have been carved mainly by water and an original structural weakness was merely the determining cause of the position of the gorge in the beginning.

A gorge may be carved by water across a range in many different ways. Firstly, as a new-born range is rising slowly out of the ocean, it may be cut across at intervals by the sea and divided into a series of islands; the channels cut thus in early times may subsequently develop into river-gorges. Secondly, the snow and rain falling on the front slopes of a range may create glaciers and rivers, which slowly cut back by head-erosion and eat through the mountains. Thirdly, the snow and ice accumulating on the crest may gravitate towards the lowest points of the range, and thence flow off in opposite directions and wear away the rock on both flanks simultaneously. Fourthly, a river may be antecedent or older than the mountains, and have maintained its

* *The River valleys of the Himalayas, an address to the Manchester Geographical Society*, 1893, by R. D. Oldham.
The evolution of Indian Geography, by R. D. Oldham, *Geographical Journal*, March, 1894.

path across the latter as they rose. Fifthly, the flow of a river may be dammed by the rise of mountains across its path, and the waters of the lake so formed may eventually overflow and carve a gorge across the barrier range.

From classifications of the known gorges of Asia geographers were led to believe that the drainage of numerous mountain basins has been dammed by the rise of recent ranges, and that the imprisoned water has risen and overtopped the crests and has eroded narrow channels in its escape. But owing to the entire absence of lacustrine deposits, geologists have been unable to accept this explanation. In view of the differences of opinion that are now existing, we cannot presume in this paper to put forward any theory accounting for the presence of the gorges. The courses of rivers across ranges may have originated, some in one way, some in another, and even a single gorge may have been partly due to one cause and partly to others.*

The charts of rivers bring home to us how different are the forms of basins. On the one hand we see the Kosi, the Karnali and the Gandak possessing numerous branches and draining immense lengths of the snowy range, and on the other we witness the Sutlej a branchless trunk issuing from Tibet and draining a narrow transverse zone of the Himalaya.

The following table shows the heights of the beds of the principal gorges through the great Himalayan range and the widths of those gorges at certain heights :—

TABLE XXXIII.

River-gorge.	Height of bed of gorge in feet near the axis of the range.	Width of gorge between commanding peaks.	Average fall per mile from peak to bed.
Kali Gandak ..	5000	12 miles at 24000 feet	3167 feet
Bhotia Kosi ..	5000	10 miles at 20000 feet	3000 feet
Bhagirathi ..	7000	11·5 miles at 20000 feet	2261 feet
Dudh Kosi ..	16000	14 miles at 22000 feet	857 feet
Sutlej ..	9000	9 miles at 20000 feet	2444 feet
Trisuli Gandak..	6000	16 miles at 19000 feet	1623 feet
Buria Gandak ..	7000	18 miles at 19000 feet	1333 feet
Kali ..	9000	6 miles at 16000 feet	2333 feet
Gori ..	10000	6 miles at 16000 feet	2000 feet
Arun ..	6000	14 miles at 16000 feet	1429 feet
Tista ..	6000	25 miles at 16000 feet	800 feet
Alaknanda ..	6000	30 miles at 16000 feet	666 feet

The proximity of high peaks to deep gorges.

The passage of a river across a range has been observed to occur in many places near the highest point of the range, but our knowledge of the Himalaya mountains is insufficient to justify any statement of a general law. Some supreme summits do not appear to stand on the edges of transverse gorges, and some of the gorges do not appear to

* "Nothing can be certain till the topography and the geology are better known": *vide The valleys of the Himalayas*, by R. D. Oldham, *Geographical Journal*, November, 1907.

have been cut on the flanks of great peaks, yet proximity has been so often noticed that it must now be regarded as a phenomenon deserving attention.

It may be that the great outbursts of granite, which go to form the high peaks, are frequently accompanied by lines of weakness in the original structure, and that whilst the peaks themselves are hard, the rocks on their flanks have feeble powers of resistance.

It may be that the high peaks have from early times, before the mountains attained their present elevation, condensed the moisture of southern breezes and caused more snow and rain to be precipitated in their vicinity than on other parts of the range, and have thus given to glaciers and streams not only a greater fall and a greater eroding power, but a greater volume. *

It may be that, as one portion of the earth's crust becomes elevated to a great height, an adjacent portion becomes depressed, in accordance with the theory of isostasy.

It may be that the highest points of ranges occur at the bends and bifurcations of the latter, and that the bays and angles formed by bends and bifurcations render such places liable to the attacks of glaciers and streams. At present we are unable to determine the cause, and the solution of the problem awaits further and more accurate observations.

The following table contains a few examples of the proximity of extreme heights and depths: all the peaks included in the table are the highest points of their respective regions.

TABLE XXXIV.

River.	Height of bed of gorge near the peak.	Range.	Peak.	Height of peak.	Horizontal distance from peak to bed.	Fall per mile from peak to bed.
	Feet			Feet	Miles	Feet
Sutlej . .	10000	Zaskar	Leo Pargial	22210	$4\frac{1}{2}$	2713
Kali Gandak .	5000	Great Himalaya	Dhaulagiri	26795	4	5449
Arkari . .	10000	Hindu Kush	Tirich Mir	25426	8	1926
Indus . .	4000	Great Himalaya	Nanga Parbat	26620	14	1616
Hunza . .	6000	Kailas	Rakaposhi	25550	9	2172
Dudh Kosi .	18500	Great Himalaya	T^{42}	25433	4	1733
Gori . . .	10000	Great Himalaya	Nanda Devi	25645	12	1304
Yurangkash .	11000	Kuen Lun	Highest peak of region.	23890	10	1289

* If the rate of flow be doubled, the force of the water is increased 64 times. The transportation of boulders, the erosion of gorges and the destruction of mountains are mainly the work of rivers when in *violent* flood.

The highest points of ranges tend to occur on transverse lines.

In the last paragraphs we dealt with the phenomenon of contrast: in this we refer to the phenomenon of sympathy. The contrasts were between neighbouring points of the same range, the sympathies are between corresponding points of different ranges.

The several parallel ranges of the Himalaya and Tibet tend to culminate in sympathy with each other: we give the following instances to illustrate our meaning.

(i) The Karakoram culminates in K^2 opposite to the Pir Panjal, which is the highest section of the outer Himalaya. Of the intermediate ranges the Punjab Himalaya culminate in Nanga Parbat, and the Kailas range in Haramosh, between K^2 and the Pir Panjal.

(ii) In the Nepal Himalaya the supreme peaks of Everest and Kinchinjunga stand on the great range opposite to what appears to be an exceptional development of the outer range.*

(iii) The Chur peak, the highest of the Nag Tibba range, stands opposite to the great Zaskar peak, Leo Pargial and to the Aling Kangri of Tibet.

(iv) A further example of sympathetic expansion we find in the Kumaun Himalaya. Here the culminating point of the great range is Nanda Devi; on a line at right angles to the range stands Kailas, the culminating point of the Kailas range; south-east of this line is Gurla Mandhata, the highest peak of Ladak range, and north-west is Kamet, the highest peak of the Zaskar range. Thus we see that all four ranges tend to increase in elevation within the same region.

(v) A fine example of sympathetic expansion is furnished by the Hindu Kush. After a stretch of 100 miles from east to west, throughout which its highest peaks rarely exceed 20000 feet, the southern Hindu Kush range rises suddenly to 24171 feet at Sad Ishtragh: immediately opposite to Sad Ishtragh the northern Hindu Kush range shows in its peak of Lunkho (22641 feet) an even more extraordinary rise. Twenty-five miles from Lunkho, north of the Oxus, appear the two highest peaks of the whole Trans-Oxus region, which combine with Lunkho and Sad Ishtragh and a peak (21297 feet) of the Kailas range on the south to form a wonderful line of maximum elevation at right angles to the direction of the ranges.

The lowest points of ranges tend to occur on transverse lines.

The above are examples of sympathetic maxima, and chart XXXVI has been drawn to illustrate sympathetic minima, and to show how the gorges or lowest points of ranges tend to occur on transverse lines.

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* Map of Nepal, scale 1 inch = 16 miles.

The following table will explain the meanings of the letters inserted on chart XXXVI.

TABLE XXXV.

A 1	The Indus turns the great Himalaya west of Nanga Parbat.
A 2	The Hunza river turns the Karakoram north-west of Rakaposhi.
B 1	Passage of the Jhelum through the Pir Panjal range.
B 2	Passage of the Indus through the Ladak range.
B 3	Shimshal pass.
B 4	Passage of the Oprang river through the Aghil range.
B 5	Passage of the Yarkand river through the Kuen Lun range.
C 1	The Chenab crosses the lesser Himalayan range.
C 2	The Zoji pass.
C 3	The Shigar river crosses the Zaskar range.
C 4	The Indus crosses the Ladak range.
	Karakoram pass.
C 5	The Karakash crosses the Kuen Lun range.
D 1	The Chenab cuts through the Pir Panjal range.
D 2	The Zaskar river cuts through the Zaskar range.
D 3	The Nubra cuts through the Kailas range.
D 4	The Yurangkash river cuts through the Kuen Lun range.
E 1	The Beas cuts the Siwalik range.
E 2	The Ravi cuts the Dhauladhar range.
E 3	Great bend in the Zaskar river.
E 4	The Shyok river cuts the Karakoram range.
F 1	The Sutlej passes the Siwalik range at an overlap.
F 2	The Beas passes the Dhauladhar range.
F 3	The Spiti-Indus water-parting bends through a right angle.
F 4	The Indus breaks through the Ladak range.
	The Pangong line of lakes bends in sympathy with the Indus.
F 5	The Kiria breaks through the Kuen Lun range.
G 1	The Jumna passes the Siwalik range.
G 2	The Sutlej crosses the great Himalaya.
G 3	The eastern branch of the Indus crosses the Kailas range.
H 1	The Ganges passes the Siwalik range.
H 2	The Ganges (Bhagirathi) crosses the great Himalaya.
H 3	The Sutlej crosses the Zaskar range.
K 1	The Alaknanda crosses the great Himalaya.
K 2	The Sutlej crosses the Ladak range.
L 1	The Kali Gandak cuts the Himalayan range east of Dhaulagiri.
L 2	The Photu pass, 15080 feet, over the Ladak range.
L 3	A northern tributary (Charta Sangpo) of the Brahmaputra cuts the Kailas range.
M 1	Knee-bend at junction of the Trisuli Gandak and Kali Gandak.
M 2	Southward bend in the Brahmaputra.

TABLE XXXV—*contd.*

N 1	The Buria Gandak cuts the great Himalaya.
N 2	A northern tributary of the Brahmaputra cuts the Kailas range.
	The Baghmati passes the Siwalik range opposite the Bhotia Kosi's passage through the great range. (Charts XXVII and XXVIII.)
P 1	The Arun Kosi breaks through the great Himalaya, lesser Himalaya and Siwalik range on one alignment.
P 2	The Brahmaputra cuts northwards through a branch of the Kailas range.
Q 1	The Ganges and Brahmaputra break between the mountains of Chota Nagpur and Assam.
Q 2	The Siwalik range is destroyed.
Q 3	Bend in the great Himalaya between Kinchinjunga and Chumalhari.
Q 4	The Nyang tributary of the Brahmaputra breaks the Ladak range.
Q 5	Northern tributary of the Brahmaputra cuts the Kailas range.
R 1	Knee-bend of the Manas river.
R 2	Lake Yamdrok.
R 3	The Kyi (Lhasa) river cuts the Kailas range.

It will be held that many of the above so-called examples of sympathy are but coincidences, and doubtless this is the case: but the total accumulation of evidence is considerable, and can hardly be dismissed as a series of accidents.

The higher range of a trough is generally the one pierced by the escaping drainage.

When a river breaks out from a trough, the range that is pierced is generally the higher of the two: rivers, for example, that rise in the Sarikol trough, escape through the higher range to the east; those that rise in the Hindu Kush trough, with the exception of two minor streams, escape through the higher range to the south; those that rise behind the Kuen Lun escape through the higher range to the north; those that rise north of the great Himalaya escape, with one exception, through the higher range to the south.

If it could be proved that the river-gorges in these cases had been caused by the overflows of imprisoned lakes, it would become evident that the higher ranges were younger, and were, at the times when the overflows were commencing, lower than their parallel companions, which they now surpass.

The gorges in the Great Himalaya compared with those of the Ladak range.

The longitudinal section in chart XX illustrates the interesting fact that no river crosses the Punjab Himalaya throughout a length of 360 miles—from the Sutlej to the Indus. The same section shows that, in other portions of the Himalaya, rivers are intersecting the great range at every 50 or 60 miles. The absence of gorges through the Punjab Himalaya seems to be due to the fact that the drainage of the northern slopes all flows towards Ladak and escapes by the Indus.

In Tibet the Indus has cut down its bed to a depth greater by 4000 feet than the Brahmaputra; this lower level of the Indus has given to its tributaries in Ladak a considerable fall, and has perhaps induced them to flow away from the Himalayan crest rather than attempt to cross it.

If we compare the great Himalayan and the Ladak ranges, we find a curious alternation existing; in Nepal the Himalaya are pierced by many gorges but the Ladak range is not; opposite the Punjab the Himalaya are not so pierced but the Ladak range is. In the region where rivers cut across the southern of the two ranges the northern range is not intersected, but where the southern range runs for a long distance intact, the northern is interlaced by the Indus.*

The gorges in the Great Himalaya compared with those of the Lesser Himalaya.

Our charts show that the great Himalayan range has been pierced by more rivers than the lesser range; † it might have been supposed that a river, which had been able to carve a deep gorge through the great range, would be able to maintain its way across the lesser range during the rise of the latter; but surveys teach us that this has not been the case. The lesser range appears to have barred the paths of many rivers, and having forced them to converge inside the mountains has restricted the number of principal basins and exits.

The Alaknanda and Bhagirathi have both cut passages for themselves through the great Himalayan range, but they unite within the mountains and pierce the lesser Himalayan and Siwalik ranges in one joint stream, the Ganges.

Three affluents of the Kali pass the great Himalayan range through independent gorges, but unite within the hills.

One branch of the Gandak, the Kali, rises in the trough behind the great Himalayan range; two other great branches rise behind the crest of that range; yet through the outer ranges there is only one outlet for the three.

One branch of the Kosi, the Arun, rises in the trough behind the great Himalayan range; five other principal branches rise in that range; yet there is but one outlet through the outer ranges.

Two principal branches of the Manas rise behind the great Himalayan range, and at least one in that range; there is but one outlet.

In the basin of the Raidak no tendency has been observed for rivers to converge; the several branches flow independently and directly out of the mountains; it is however in this basin that the lesser Himalayan and Siwalik ranges are absent.

* We have already described how the Indus in Ladak passes backwards and forwards three times across the Ladak range; it intersects it first near Thangra; at Skardo it crosses back again to its original flank and trough; and at Bunji it pierces the same range again.

† We are referring here to the outer parallel range of the lesser Himalaya, that traverses Nepal and Kumaun, and not to the oblique ranges, *vide* frontispiece chart of Part I.

If we compare the northern and southern borders of the Tibet plateau, the Kuen Lun and the Himalaya, we find that rivers do not converge in the former to the same extent as in the latter, that the basins of the former are narrower, and that the number of rivers issuing from the same length of Kuen Lun is three times as great as the number from the Himalaya.

The cause of this difference is obvious; an outer Kuen Lun range has not dammed its rivers, as the lesser range has done in the Himalaya.

29

THE GLACIERS OF HIGH ASIA.

Former vast extensions of glaciers.

Large and numerous as are the existing glaciers of the Himalaya and Karakoram, they are but the relics of an older and more extensive series of ice-flows. The ancient moraines, the perched blocks and the glaciated surfaces all furnish proofs that the ice in former times covered an area in Asia immensely larger than at present.

On the southern slopes of the Dhauladhar range an old moraine was discovered by the late General McMahon at the extraordinarily low altitude of 4700 feet: * and on the Tibetan side of the Great Himalayan range the glaciation appears at one time to have been almost universal. No reliable observations have yet been made in central or northern Tibet, but in Ladak, in Nari Khorsam, and in Tsang the vast moraines and the transported blocks, perched high on hill sides far from their parent mass, are indications of the former existence in southern Tibet of an almost continuous ice-sheet, and of snow-fields and glaciers, such as are now to be found in polar regions only.

The diminution in the extent of the glaciers of the Trans-Himalayan region has been ascribed to the growth of the great range, which is supposed to have slowly risen and barred the passage of the moisture-laden winds from the south.† But this explanation cannot be regarded as complete, for the decrease in the ice has been as marked on the southern flank of the Himalaya as on the northern.

Secular changes in glaciers.

Although the Himalayan glaciers were at one time far more numerous and extensive than at present, their diminution does not appear to have progressed continuously. The process of contraction seems to have been interrupted at times, and the ice has at intervals spread again over areas, from which it had previously retreated.

Evidence of three separate periods of glacial extension has been discovered by Oldham in Kashmir,‡ and similar oscillations have been observed by Huntington in the Pangong valley of Ladak.

A complete study of Himalayan glaciers has long been recognised as desirable, and numerous references to the subject will be found in the writings of Hooker, Drew, Godwin-Austen and others, and in the records and memoirs of the Geological Survey; § but it has only recently become possible for Indian geologists to commence systematic observations. During the summer of 1906, certain glaciers in Kumaun, Lahaul and

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* *Records, Geological Survey of India,* Vol. XV (1882), p. 49.

† *A Manual of the Geology of India, 2nd Edition,* page 486.

‡ *Records, Geological Survey of India,* Vol. XXXI, pt. 3.

§ *Hooker's Himalayan Journals,* Vol. II, p. 7.
Journal, Asiatic Society of Bengal, Vol. XL, pt. 2, p. 393: Vol. XLIV, pt. 2, p. 209: Vol. XLVI, pt. 2, p. 1.
Memoirs, Geological Survey of India, Vol. III, pt. 2, p. 155: Vol. XIV, p. 116.
Records, Geological Survey of India, Vol. VII, p. 86: Vol. X, pp. 123, 140.
Drew's Jummoo and Kashmir territories.
Quarterly Journal, Geological Society, Vol. XXIX, pp. 441, 466: Vol. VII, p 310.

Kashmir were observed, and the positions of their snouts accurately determined; these measurements will form a basis for subsequent work and will enable future observers to ascertain, whether the glaciers are advancing or retreating.*

For many years systematic observations have been made in Europe, and almost every glacier has been found to be retreating.

In the Tian Shan mountains, on the other hand, there is but one glacier only, the Mushketoff, which shows signs of recent retreat.†

In the case of the Himalayan glaciers the *present* direction of secular movement has never yet been determined, but so far as we are able to judge from the mechanical records left by the ice itself and from local traditions, no general rule obtains, such as has been observed to hold in the Alps. Certain Himalayan glaciers appear now to be retreating, others show signs of advance, and others again seem to have remained stationary for a considerable period.

In Hunza-Nagar two glaciers are known, which have advanced rapidly ot recent years, and which have spread over fields and stopped cultivation.‡ On the other hand, the snout of the Milam glacier in Kumaun is retreating: the Pandit Kishen Singh—the A-K of Tibetan exploration—states that the glacier at Milam has receded 100 paces in his lifetime of 55 years. "The tradition of my village," he writes, "runs "that the glacier at one time descended almost to within a line with our houses, but "it is now a mile above them."

It will be many years before we shall be able to generalize upon the direction of the secular movement of the Himalayan glaciers. It is difficult to arrange for surveys to be made of all large glaciers, and travellers will be able to render assistance of great value, if they will but take detailed observations of the present positions of the snouts, that they visit. Co-operation such as this will be necessary to render our records complete.

Seasonal variations and subordinate phenomena.

The direction and rate of secular movement are perhaps the most important points for investigation. But other observations of interest are required. The seasonal variations in the lengths of glaciers and the relations of these variations to meteorological conditions will have to be observed. The nature of the ice, the position and movements of the 'dirt-bands,' the lamination, the directions of cracks and crevasses, and the rates of abrasion of the bed of the glacier, both in solid rock and in unconsolidated moraine, are all objects worthy of the attention of observers.

The rate of flow of the ice has also to be determined: this will vary with the gradient of the bed. A *transverse* glacier,—that is a glacier which flows down a valley at right angles to a range—is more likely to have a steep slope than a *longitudinal* glacier, or one occupying a trough between two ranges

* *General Report, Geological Survey of India*, 1906, by T. H. Holland, F.R.S., Director, and *Records, Geological Survey of India*, Vol. XXXV.

† Merzbacher's *Central Tian-Shan Mountains*, p. 192.

‡ Conway's *Climbing and Exploration in the Karakoram Himalayas*.

The longitudinal glaciers of the Karakoram are the greatest ice-flows of the world, outside polar regions: their gradients are gentler than those of the transverse glaciers. Their snouts too are generally situated at higher altitudes than those of the transverse glaciers: the great longitudinal glacier in Hunza-Nagar, known as the Hispar, terminates at an elevation of 10500 feet above sea-level, whilst the transverse glaciers on the slopes of Rakaposhi descend below 8000 feet; the steepness of the gradients on Rakaposhi allows the ice to reach lower altitudes, before being melted.

For the determination of secular movements, longitudinal glaciers like the Hispar, Biafo, Baltoro and Chogo Lungma are, perhaps, more suitable for observation than the transverse. When the snowfall has been abnormally heavy or light for one or more seasons, the lengths of the transverse glaciers are apt to be temporarily affected, and observations confined to a few years lead then to erroneous conclusions. If, however, observations are extended over long periods, there should be no difficulty in disentangling the effects of secular movement from those of seasonal variation.

The principal glaciers of High Asia.

A great number of the glaciers of the Himalaya and Tibet have been roughly surveyed and the altitudes of their snouts determined, but it would be no more possible to classify or enumerate them than it would be to classify or enumerate the rivulets. Glaciers abound at the source of every great river and throughout the mountain ranges.

The following glaciers of High Asia are known to exceed twenty miles in length:—

TABLE XXXVI.

Name of glacier.	Length.	Region.	Position.
Inylchek	44 miles	Tian Shan	. . .
Biafo	39 miles	Karakoram	Parallel to the Indus in the trough between the Karakoram and Kailas ranges.
Hispar	25 miles	Karakoram	
Baltoro	36 miles	Karakoram	In the trough between K^2 and Masherbrum on the summit of the Karakoram range.
Koikaf	31 miles	Tian Shan	. . .
Chogo Lungma	24 miles	Karakoram	Parallel to the Biafo and 13 miles south; parallel also to the Indus.
Gasherbrum	21 miles	Karakoram	South of Gasherbrum peaks.
Saichar Ghainri	21 miles	Karakoram	At the source of the Nubra.
Semenoff	20 miles	Tian Shan	. . .

No glacier of the Himalaya attains a length of 20 miles: the Rupal glacier near Nanga Parbat was described by one observer as descending to the village of Tashing and as being 22 miles long, but this account is known to have been inaccurate.

The maps of the Survey of India show the Rupal glacier to be ten miles in length, and they represent *other* glaciers entering the Rupal river from lateral valleys *between* the snout of the principal glacier and Tashing village. In the depths of winter these several glaciers are buried under a continuous mantle of snow, but at the periods of survey they were apparently unconnected.

The following table contains a list of the best-known glaciers of High Asia.*

TABLE XXXVII.

Region.	Name of glacier.	Length.	River into which it drains.
Sikkim Himalaya †	Zemu	16 miles	Tista.
	Kinchinjunga	13 miles	Tambar.
	Yalung	10 miles	Tambar.
Nepal Himalaya	No positive information. Structural troughs may exist in the crest-zone of the Nepal Himalaya, but they are at present quite unknown. Many deep ravines and notches have been cut by rivers across the Himalayan crest, and it is a question whether the sections of the range intervening between them, are sufficiently long and sufficiently intact to hold glaciers rivalling the Biafo. It is well known that glaciers extend over large areas on the slopes of Everest and Makalu.		
Kumaun Himalaya ‡	Milam	12 miles	Gori (Kali).
	Round north base of Nanda Devi.	12 miles	Dhauli (Alaknanda).
	Round south base of Nanda Devi.	12 miles	Dhauli (Alaknanda).
	Satopanth	7 miles	Vishnuganga at Badrinath.
	Bagini	10 miles	Dhauli (Alaknanda).
	Kosa	7 miles	Dhauli (Alaknanda).
	Mana	12 miles	Jahnavi (Bhagirathi).
	Kedarnath	9 miles	Bhagirathi.
	Gangotri	16 miles	Bhagirathi at Gau Mukh.
Punjab Himalaya §	Rupal (northern)	10 miles	Are cutting Nanga Parbat off from the great Himalaya and draining into the Indus.
	Rupal (southern)	11 miles	
	Phungatori	9 miles	Drain into the Indus from the northern slopes of Nanga Parbat.
	Rakiot	8 miles	
	Diamir	7 miles	Drains into the Indus from the western slopes of Nanga Parbat.
	Gauri	7 miles	From the Nun Kun peaks into the Suru.
	Shafut	8 miles	
	Barmal	8 miles	Wardwan.

* The list is not complete: the information upon which it is based is defective.

† *Round Kangchenjunga*, by Douglas Freshfield, North-East Trans-Frontier Sheet, 7 N. W.

‡ Atlas Sheets 65 and 66 N. E. and 66 N. W. Kumaun and Garhwal Survey, Sheets 12 and 20.

§ Atlas Sheets 46 and 45 S. W.: Northern Trans-Frontier Sheet 3 N. E.: Map of Kangra. The glaciers in Kulu are never 5 miles in length, and those of Spiti are smaller.

TABLE XXXVII—*contd.*

Region.	Name of glacier.	Length.	River into which it drains.
Punjab Himalaya	Rundun	12 miles	Suru.
	Durung	14 miles	Suru.
	Kungi	11 miles	Zaskar.
	Hagshu	9 miles	Zaskar.
	Muni	11 miles	Zaskar.
	Gowra	8 miles	Zaskar.
	Reru	10 miles	Zaskar.
	Prool	8 miles	Wardwan.
	Brama	10 miles	Wardwan.
	Tuan	10 miles	Chandra Bhaga.
	——	9 miles	Chandra Bhaga.
	Sisu	7 miles	Chandra.
	Sonapani	7 miles	Chandra.
	——	10 miles	Chandra.
	Nilang	7 miles	Bhaga.
	Nela	10 miles	Sutlej.
	Nithal	10 miles	Sutlej.
Lesser Himalaya (Punjab)	Sha	6 miles	Into the Bara Bangahal basin and thence into the Ravi.
Karakoram*	Biafo	39 miles	Braldo.
	Hispar	25 miles	Hunza.
	Baltoro	36 miles	Braldo.
	Gasherbrum	21 miles	Shyok.
	Chogo Lungma	24 miles	Shigar.
	Remo	15 miles	Shyok.
	Saichar Ghainri	21 miles	Nubra.
	From Rakaposhi	11 miles	Hunza.
	Malungatti	22 miles	Hunza.
	Barpu	19 miles	Hunza.
	Batura	20 miles	Hunza.
	Pasu	14 miles	Hunza.
	Daintar	13 miles	Hunza.
Hindu Kush †	Kurkulti	10 miles	Hunza.
	Wasmu	7 miles	Kunar.
	Rich	10 miles	Kunar.
	Sakiz Jarab	19 miles	Kunar.
	Sad Ishtragh	8 miles	Kunar.
	Tirich Mir	14 miles	Kunar.

* Bullock Workman's *In the Ice World of Himalaya*, p. 119. Map of Turkistan, Atlas Sheet 44a S.E., Northern Trans-Frontier Sheet 2 S.E.

† Northern Trans-Frontier Sheet No. 2, and North-West Trans-Frontier Sheet No. 26.

TABLE XXXVII—*contd.*

Region.	Name of glacier.	Length.
Kuen Lun . . .	Nissa . .	10 miles.
Kashgar Range*	Yambulak . .	6 miles.
	Koch Korche .	9 miles.
	Koksei . .	9 miles.
Tian Shan	Inylchek . .	44 miles.
	Koikaf . . .	31 miles.
	Semenoff . .	20 miles.
	Jiparlik . . .	16 miles.
	Mushketoff . .	13 miles.
	Sabavchy . .	14 miles.

Many travellers have remarked upon the dirty colouring of the Himalayan glaciers and have lamented the absence of the beautiful blue-green hues of Norway and Switzerland. The discolouration of snow and ice in the Himalaya is due to dust which is brought by wind in immense volumes from India, Baluchistan and Persia, and deposited upon the mountains of Tibet.

Altitudes to which glaciers descend.

In Sikkim, Kumaun and Spiti the glaciers of our time rarely descend to 11000 feet: indeed it may be questioned whether any instance of a descent to 11000 feet has been discovered in those regions. But in the Karakoram the glaciers frequently descend to 10000 feet. This difference is without doubt partially due to the higher latitude of the Karakoram, but other causes for it exist, and these may possibly be producing even greater effects than the difference in latitude. The great peaks and high snow-clad ridges rise from the glaciers more abruptly in the Karakoram than in the Himalaya, and the horizontal distances between the valleys and the snow-fields which feed them from either side, are less; the slopes are consequently steeper and the glaciers are able to descend to lower altitudes, before their ice is melted.

The longitudinal glaciers of the Karakoram flow, it is true, down gentle gradients, and at 10000 feet portions of their ice are still surviving the attacks of heat. It is because they possess such immense volumes of ice, that these glaciers are able to reach low altitudes.

Differences between glaciers on northern and southern slopes.

Between the valley of the Sutlej in Kanawar and the Nun Kun peaks in Kashmir, the glaciers are few and small, but those on the northern slopes of the ranges are invariably more extensive than those on the southern. In the Punjab Himalaya several glaciers of the northern slopes exceed 11 miles in length, and some exceed 12; but the largest glacier of the southern slopes has a length of 10 miles, although the snowfall south of the crest is known to be greater than that to the north. Similar differences indeed are to be observed throughout the Himalaya. They are probably due to the greater amount of solar heat received by the southern slopes.

* Stein's Map.

30

THE LAKES OF TIBET AND TURKISTAN.

If we examine chart XXIII, which illustrates the basins of the great rivers that drain the plateaux of Asia, we find that in addition to the low-lying self-contained basin of Tarim, there is beside it a very large high-level basin in Tibet, which possesses no outlet for drainage.

Throughout the Tian Shan, the Pamirs and the Himalaya there are inland basins without outlets, but no one of them approaches in size the lake-basin of Tibet, or is indeed large enough to be shown on such a small scale as that of chart XXIII.

Though the Tibet lake-basin is very extensive and is studded throughout with lakes, it contains no single lake that will compare in area with the great lakes of the world.

The area of lake Superior in America is 30000 square miles; the area of the Sea of Aral is 25000 square miles; the areas of the Asiatic lakes Balkash and Baikal are respectively 9000 and 10000 square miles.

The largest lake enclosed among the high mountains of Asia is Issik Kul in the Tian Shan, area 2000 square miles. The largest lake of Tibet is Koko Nor, area 1630 square miles.*

In the following tables are given the heights, areas, lengths, and (when available) the depths of the principal lakes of Tibet and Turkistan. Many hundreds of lakes have been discovered by explorers in High Asia, but the greater number possess areas of ten or fifteen square miles only, and have been excluded from the lists. The names of small lakes have, however, been included for those regions in which no large lakes exist. In the Karakoram and Hindu Kush there are no lakes of importance.

TABLE XXXVIII.—The principal Lakes in the Mountain regions surrounding Tibet.

Region.	Name.	Area in square miles.	Maximum length in miles.	Altitude above the sea in feet.	Maximum depth in feet.
TIAN SHAN.	Issik Kul	2000	115	5300	..
	Sairam Nor	200	20	5900	..
	Son Kul	102	19	9400	..
	Chadir Kul	82	14	11195	..
TARIM BASIN.	Baghrash Kul	630	50	3400	..
	Lob Nor (northern)	150	65	2600	31
	Lob Nor (southern)	220	26	2590	14
	Baba Kul, No. 1	120	..	..	..
	Baba Kul, No. 2	80	..	..	..

*As we pointed out on page 126 Koko Nor is situated on the Tibet plateau, but not in the Tibet lake-basin.

TABLE XXXVIII.—The principal Lakes in the Mountain regions surrounding Tibet.

Region.	Name.	Area in square miles.	Maximum length in miles.	Altitude above the sea in feet.	Maximum depth in feet.
PAMIR REGION.	Great Kara Kul .	140	14	13430	756
	Rang Kul .	61	20	12700	6
	Yeshil Kul .	30	15	12460	Very deep.
	Sir-i-Kul (Lake Victoria) . .	30	14	13398	..
	Little Kara Kul .	10	4	12201	79
	Chakmaktin .	8	5	13021	..
KUEN LUN MOUNTAINS.	Aig Kum Kul .	250	38	11710	..
	Achik Kul .	240	26	..	..
PUNJAB HIMALAYA: (on the Tibetan side of the crest-line).	Tso Morari .	46	16	15000	250
	Tso Kyagar .	..	..	15690	67
	Tso Kar . .	..	..	15684	..
PUNJAB HIMALAYA: (on the Indian side of the crest-line).	Wular . .	44	11	5187	14
	Dal . . .	8	4	5200	15
KUMAUN HIMALAYA.	Naini Tal . . (A group of small lakes.)	..	..	6400	..
NEPAL HIMALAYA: (on the Tibetan side of the crest-line).	Palgu Tso .	40	10	15000	..
	Tso Motretung*	40	15	14000	..
NEPAL HIMALAYA: (on the Indian side of the crest-line).	Khewan Tal .	6	3	..	..
	Damodur Kund .	2	2	..	..
	Gum Chu . .	5	3	..	..
	Dudh Kund .	5	3	..	..
ASSAM HIMALAYA: (on the Tibetan side of the crest-line).	Tso Tigu . . .	51	14	15500	..
	Tso Phomo Chang	20	17	16050	..
	Tso Rombudsa .	20	9	..	..

* Formerly called Chomto Dong in the reports and maps of the Survey.

TABLE XXXIX.—The principal Lakes of Tibet.

Name.	Area in square miles.	Maximum length in miles.	Altitude above the sea in feet.	Maximum depth in feet.
Koko Nor	1630	67	10700	..
Nam Tso	950	53	15190	..
Zilling Tso	720	45	14000	.
Dangra Yum Tso	540	45	16580	..
Yamdrok Tso	340	44	14350	..
Montcalm	300	48	16273	..
Kyaring Tso	290	41	15840	..
Kara Nor	250	26	..	..
Nganzi Tso	250	26	..	..
Oring Nor	250	26	13704	..
Naktsong	230	20	..	..
Pangong	230	98	13930	142
Tsaring Nor	220	26	13704	..
Tossun Nor	190	36	..	..
Dara Tso	180	23	..	..
Bum Tso	140	30	15000	..
Mokieu Tso	140	27	..	..
Addan Tso	140	24	..	..
Manasarowar	133	16	14900	..
Shemen Tso	120	22	15500	..
Rakas Tal	100	19	14850	..

Nam Tso is, perhaps, better known to geographers as Tengri Nor.

Yamdrok is the famous ring lake formerly known in geography as Palti,* shown first on D'Anville 's map; it is now known that the water of the lake does not *surround* the Tungchen mountain entirely; the mass of the latter is connected with the mainland by two isthmuses.

Table XXXIX contains a list of all the known Tibetan lakes that exceed 100 square miles in area. The list is doubtless incomplete and inaccurate; there may exist in Tibet a vast number of lakes that have not as yet been discovered, and the dimensions even of those lakes that are entered in the table must be regarded as first approximations only.

Many of the lakes of this table, such as Yamdrok, Manasarowar and Koko Nor, though situated in Tibet, lie outside the Tibet lake-basin.

In addition to the lakes enumerated in table XXXIX there are in Tibet numerous smaller lakes of which the Survey of India possesses measurements.

The area *known* to be under water in Tibet is 14000 square miles; the actual area under water is considerably larger than this.

* Also called Piahte and Pede. For Ryder's note on this lake see *General Report, Survey of India*, 1903-04, Appendix, p. xvii; see also his map, *Geographical Journal*, Vol. XXVI.

The principal *extinct* lake of Tibet is the Tsaidam depression; it is 300 miles long, and its trough is 100 miles broad, and 40 miles broad on the flat; it possesses an area of 12000 square miles of salt desert at an elevation of 9000 feet. It is a long flat basin filled up with detritus.

It is interesting to note that throughout the continent of Asia, there is no water-parting line between the Indian and the Arctic oceans; instead of an elevated line crossing the central portion of the continent from east to west there is a succession of closed basins:—the Tibet lake-basin, the Tarim basin, the basin of Lake Balkash, the basin of the Helmand, the Aral basin, and the Caspian.

No range of mountains can be found—not even a single peak—from which the water flows on one side into the Indian Ocean and on the other into the Arctic. The absence of a continental divide is probably due to the great distance and to the mountain barriers, which intervene between Central Asia and the sea. If the moisture-laden winds from the Arctic, Pacific and Indian Oceans could penetrate and give heavy rains to Central Asia, the volumes of the Tarim, Helmand, Oxus and Jaxartes would be increased, and outlets to the sea would be forced.

31

ON THE ORIGIN OF LAKES.

The Tibetan Lakes.

Until comparatively recently the origin of the lakes of Tibet was ascribed to the damming of river valleys by the talus fans of their tributaries; this hypothesis, which was put forward by Mr. Drew * to explain the origin of such lakes as Pangong and Tso Morari in Ladak, and has even been extended to the valley of Kashmir, was based on the fact that in all cases the visible barriers of the lakes are composed of detrital matter. It was, however, pointed out by Mr. R. D. Oldham that, under normal circumstances, a main stream would in all probability be able to keep its channel open and that unless supplemented by other causes the mere deposition of talus could hardly be considered adequate. If, however, elevation of the river-bed were to take place at a rate greater than the rate of erosion of the river, a barrier would be formed and eventually a talus dam would accumulate across the valley.†

That certain lakes in Tibet have been formed in the manner suggested by Mr. Oldham, seems to us probable, and the curious reversal of drainage recorded by the writer at the head of the Rong Valley in Central Tibet seems only capable of explanation on the assumption of a rise of the valley-bottom near the former outlet of Yamdrok Tso,‡ but it is doubtful whether this or indeed any other hypothesis can be of general application.

In some cases, as for instance in that of Kala Tso, a lake would appear to have been clearly caused by the damming of a valley by extensive moraine material brought down by a glacier from the neighbouring mountains, and it is probable that in many cases the lake dams must be attributed to glaciers rather than to rivers.

By a slight modification of Mr. Drew's hypothesis it seems, however, that the origin of many of the Tibetan lakes might be explained without the necessity for assuming concomitant crustal movement. It has been objected by Mr. Oldham that a river would most probably be able to keep its channel open in spite of the material brought down by its tributaries. One of the most marked features in connection with the development and growth of a river system is the tendency of certain branches to grow at the expense of others by cutting into or "capturing" their drainage areas and even by actually tapping a neighbouring tributary at some point in its course; this latter process is known as "beheading." If, therefore, either owing to the beheading of the main stream or to its own vigorous growth by capture, a tributary were to become the predominant affluent of a river system, then owing to its increase of volume and consequent increase of transporting power the amount of material brought

* *Jummoo and Kashmir territories.*

† *Records, Geological Survey of India,* Vol. XXI (1888), p. 156.

‡ H. H. Hayden: *Memoirs, Geological Survey of India,* Vol. XXXVI, pt. 2.

down by it would be correspondingly increased. If at the point where it debouched into what was formerly the main valley, the latter were broad and open, its rate of flow would be checked and the transported material might thus be deposited to form a dam across the valley. Such might indeed have been the origin of Tso Morari in Rupshu, the formation of which has been ascribed by Mr. Oldham to an elevation of the river-bed at a point below the present dam. This principle, however, would not apparently be applicable to Pangong. Here a long and narrow valley holds a series of lakes, which were ascribed by Mr. Drew to dams built up by tributary streams; this hypothesis has been rejected not only by Mr. Oldham, but also more recently by Mr. Ellsworth Huntington * who regards the valley as a true rock-basin carved out by a glacier. Such lakes are not uncommon in other parts of the world, but, with the exception of the small lakes in the Kumaun Himalaya, none of those in the Himalaya or Tibet have been hitherto attributed to this cause.

Thus for the mode of origin of the Tibetan lakes, three hypotheses have been put forward:

(1) the damming of the main valley by the fans of tributaries (*Drew*);

(2) rise of the river-bed and consequent deposition of material above the barrier so formed (*Oldham*);

(3) the filling of a rock-basin previously scooped out by a glacier (*Huntington*).

The further suggestion, now made by us, that the damming of the main valley may have taken place owing to its conversion into a tributary valley may be regarded as a modification of Mr. Drew's hypothesis, and if we add to this the damming of tributary valleys by moraines of glaciers occupying the main valley, we shall probably have included all the causes at work to form the more important lakes of Tibet. But we are not disposed to think that any single theory can be of universal application: thus Kala Tso may be regarded as a type of the first hypothesis (with its corollaries), Yamdrok Tso of the second and, according to Mr. Huntington, Pangong is a type of the third.

Glacial Tarns.

We have not yet referred to the innumerable tarns found throughout the higher still glaciated valleys; these, however, offer no difficulties; they are, in almost every instance, merely ponds, each caused by the damming up of its valley by the terminal moraine of a retreating glacier.

The Kumaun Lakes.

Turning now from the Tibetan uplands to the lower valleys of the Himalaya, we find in Kumaun, nestling among the forest-clad hills, a small group of lakes of which Naini Tal and Bhim Tal are the best known. Their size is insignificant, but they are of interest owing to the rarity of such lakes in the Himalaya. Many theories have been propounded to explain their origin; they have been ascribed to glaciers, to landslips, such as that which caused the formation of the famous Gohna lake in 1894,† to faulting or other

* "Pangong: a glacial lake": *Journal of Geology*, Vol. XIV (1906), p. 599.

† T. H. Holland: *Records, Geological Survey of India*, Vol. XXVII (1894), pt. 2.

earth movements and lastly to removal, by solution, of the underlying rock. The first of these theories has now been generally discarded; the second applies to Khurpa Tal and other small lakes near Naini Tal; but the origin of Naini Tal itself still remains uncertain and may be due either to the elevation, by sudden faulting or by slow and gradual rise of the crust, of part of the lower end of a pre-existing valley, or to the gradual eating away, by percolating water, of the limestone underlying the central part of the valley: by this latter process would be formed cavities and "swallow-holes," which gradually becoming enlarged to underground caves would lead to a collapse of the surface over a considerable area; such a process is common when the prevailing rock is limestone and may be observed on a small scale in many places in the hills around Naini Tal.*

The last lakes to which we have to refer are those of the valley of Kashmir. Here we find a great alluvial flat through which the Jhelum meanders in its sluggish bed till it falls into the Wular lake at its south-eastern corner. Seen from the high hills to the north, this lake looks like a mere inundated corner of the great Srinagar plain, and with its marshy borders bears a most striking resemblance to the typical "jhil" or "bhil" so common in the alluvial plains of Bengal. By Mr. Oldham, this small and shallow lake, as also that of Dal in the neighbourhood of Srinagar, was regarded as an inundated hollow in the alluvial plain, and this theory has been supported by Dr. Karl Oestreich in his recent paper on the valleys of the North-West Himalaya.†

Dr. Oestreich, however, goes a step further than Mr. Oldham and attributes their formation to deposition of alluvial dams by the Jhelum, thus increasing the analogy to the *bhils* of the Gangetic plain.

Desiccation of lakes.

That the lakes of Tibet were once very much larger than they now are is almost universally admitted.‡ This has been inferred from the salt-covered flats and dry basins which are so common on the plateau of Tibet, as well as from the old beaches seen on the hill-sides far above the present water-level, which show that the lakes once stood many hundred feet higher and spread over much larger areas than they occupy at the present day.

Thus it has been recorded by almost all explorers who have visited the great lake-basin of Tibet § that almost every individual lake is surrounded by old terraces extending to as much as 200 feet above the present water-level. This feature, too, is clearly visible on the shores of the lakes nearer to India, such as Tso Morari, Kala Tso, Yamdrok || and Pangong, ¶ of which the last shows a large series of old beaches, which remain as records of the rise and fall of the level of the lake. Much interesting information may be gleaned from these old lake terraces and in the case of Pangong,

* C. S. Middlemiss: *Records, Geological Survey of India*, Vol. XXIII (1890), p. 228.
† *Petermann's Mitteilungen, Erg. No.* 155 (1906).
‡ *A Manual of the Geology of India, 2nd Edn.*, p. 486.
F. Drew: *Jummoo and Kashmir territories*, pp. 292-300.
R. Lydekker: *Memoirs, Geological Survey of India*, Vol. XXII, p. 28.
Journal, Royal Geographical Society, Vol. XLVII (1877), p. 107.
§ G. R. Littledale: *Geographical Journal*, Vol. VII (1896), p. 474.
H. H. P. Deasy: *In Tibet and Chinese Turkistan*, p. 32.
C. G. Rawling: *The Great Plateau*, p. 110.
|| H. H. Hayden: *Memoirs, Geological Survey of India*, Vol. XXXVI, pt. 2.
¶ Ellsworth Huntington: *Journal of Geology*, Vol. XIV (1906), p. 599.

Mr. Huntington regards them as evidence of desiccation, it is true, but of a desiccation that was oscillatory, embracing periods "now drier, now wetter, but the tendency "to aridity generally greater than its opponent."

That the marked contraction in volume of the lakes is due in many cases to evaporation is proved by the intensely saline character of their waters and, like the decrease of the glaciers, it has been attributed to a gradual process of desiccation consequent on the rise of the Himalayan ranges.* That very extensive desiccation has occurred, since the period of greatest extension of the glaciers and the (possibly subsequent) great extension of the lakes, may be safely regarded as an established fact, but whether such a process is still operative is a question which can only be decided by regular and systematic observations extending over long periods of time. The isolated observations made by explorers during the last hundred years in various parts of Tibet are inconclusive, as well as being at times mutually contradictory. This is especially noticeable with regard to two features, outflow and salinity.

It has been generally observed that most Tibetan lakes have no superficial outlet, but at the same time it is by no means unusual to find that there is a well-marked channel through the old river gravels which fill the former outlet, and that this channel, though dry at present, shows evidence of outflow having taken place at no very distant date; such channels are to be seen—to cite the more familiar instances—on Manasarowar in Nari Khorsam, and on Tso Motretung and Kala Tso in Tsang. The well preserved state of these channels shows that either they have only recently become dry or that they are still in intermittent use and the fact that the accounts of different explorers regarding the same channel are often mutually conflicting rather lends colour to the latter alternative. Hence the presence of a dry channel cannot be taken as conclusive proof that desiccation is still in progress, especially as in certain cases—as for instance from Kala Tso—outflow takes place beneath the surface of the deposits through which the superficial channel runs.

Similarly, although the fact that the waters of a given lake are salt may be taken as proof that desiccation has been operative, yet any attempt to establish the continuance of this tendency at the present time is frustrated by the want of systematic observations. This is, in fact, even more noticeable with regard to the salinity than in the case of observations regarding outlets. There is no doubt that many lakes, especially the smaller ones—such as Kyagar Tso and the salt lake of Ladak—are permanently and very markedly salt, but in many others the salinity varies in the most striking manner, water found quite undrinkable by one explorer having been subsequently regarded as perfectly fresh by another: a particularly good example of this peculiarity is furnished by the Aru Tso, which lies in Western Tibet due east of Leh.

This lake was visited in 1891 by Captain Bower,† who writes that the waters were "salt of course, like all the Tibetan lakes." In 1897, Captain Deasy‡ remarked that

* R. D. Oldham: *Rec., Geol. Surv. India*, Vol. XXI (1888), p. 157.
† H. Bower: *Across Tibet*, p. 35.
‡ H. H. P. Deasy: *In Tibet and Chinese Turkistan*, p. 31.

the water was "drinkable," whereas in 1903 it was found by Captain Rawling* to be "without the slightest flavour of salt or soda."

It is evident, therefore, that this character is largely dependent on seasonal variations† and, unless proved to be permanent, cannot be regarded as evidence of *progressive* desiccation.

Admitting, however, that desiccation has occurred to a very great extent in the past, it remains to be proved whether or no it is still operative. This can only be ascertained by systematic observations of the water-level and salinity of certain selected lakes. If we are correct in ascribing the observed desiccation to decreased rainfall due to the rise of the Himalaya, it is evident that if such rise is still in progress and if the rate of elevation exceeds the rate of degradation, then a steadily decreasing amount of moisture will reach the plateau of Tibet; that is to say, if the Himalaya as a mountain system have not yet reached maturity, it is to be expected that desiccation will still be in progress. When, however, this stage has been reached, it may be expected that the rainfall of Tibet will become approximately constant and such variations as may be observed will be of merely seasonal significance, and when, finally, degradation outweighs growth and the Himalaya pass into a stage of decay, the climate of Tibet will become increasingly moist and the lakes and glaciers will regain some measure of their former grandeur. In this connection observations have recently been begun by the Trigonometrical Survey from selected stations near Dehra Dun with a view to determining the absolute values of Himalayan heights and thus eventually to detect any variations that may have taken place in the heights of the great peaks: but it must be remembered that geological processes are usually so gradual as to be almost imperceptible during such periods of time as can be measured by human standards and the many disturbing factors, already referred to in a previous part of this paper, may render it impossible to detect with certainty such movement as may take place in the course of a single century.

Although the hypothesis of a rise of the Himalaya may fully suffice to account for the desiccation observed in the neighbourhood of the mountains and in the great lake-basin of Tibet, it is by no means certain that it can be applied to such areas as the Tarim basin. The disappearance of lakes in this and similar desert areas, such as Baluchistan, has been attributed to the increase and movements of blown sand.‡ The surface rocks of Tibet are everywhere decomposing, and the several rivers that have their sources in Tibetan glaciers carry down immense loads of sand. The annual additions of sand to the deserts of Asia are always increasing the amounts already accumulated in past centuries. The Tarim basin is becoming choked with sand; almost all its rivers now end in its deserts and fail to reach Lob Nor. The sand is always increasing whilst the water is not.

* C. G. Rawling: *The Great Plateau*, p. 111.

† It has also been pointed out by Mr. Ellsworth Huntington that salinity is largely affected by circulation of the water in a lake and a single observation might thus be entirely misleading: see '*Pangong: a glacial lake.*' *Journal of Geology*, Vol. XIV (1906), p. 599.

‡ S. G. Burrard: *Report on Geography to the Board of Scientific Advice for India*, 1905-06.

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to the more important

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* The picture of Bandarpunch peak will be found facing p. 39 of Part I.

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* The name Sangpo should have been spelt Tsangpo. The Imperial Gazetteer of India on pages 19 and 27, Vol. I, and on page 499, Vol. IV spells it Tsan-po.

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* On this Chart Hoang Ho is wrongly spelt Huang.

† The name Sangpo should have been spelt Tsangpo. The Imperial Gazetteer of India on pages 19 and 27, Vol. I, and on page 499, Vol. IV spells it Tsan-po.

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* The picture of Nanga Parbat peak will be found facing p. 39 of Part I.
† This name should have been spelt Ngari Khorsum (H. H. Hayden).

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* The picture of Nojli Tower will be found facing p. 30 of Part I.

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† Shigatse, spelt thus on the map of the Imperial Gazetteer, is written Shi-ga-tse by Captain O'Connor and Shigatse on page 119, Vol. IV of the Imperial Gazetteer.

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* Zaskar is the form of spelling adopted in the Imperial Gazetteer. Mr. Hayden writes "Ladakhis pronounce the "name Zangskar, Central Tibetans pronounce it Zangkar, Kashmiris pronounce it Zaskar."

CHART XXIII

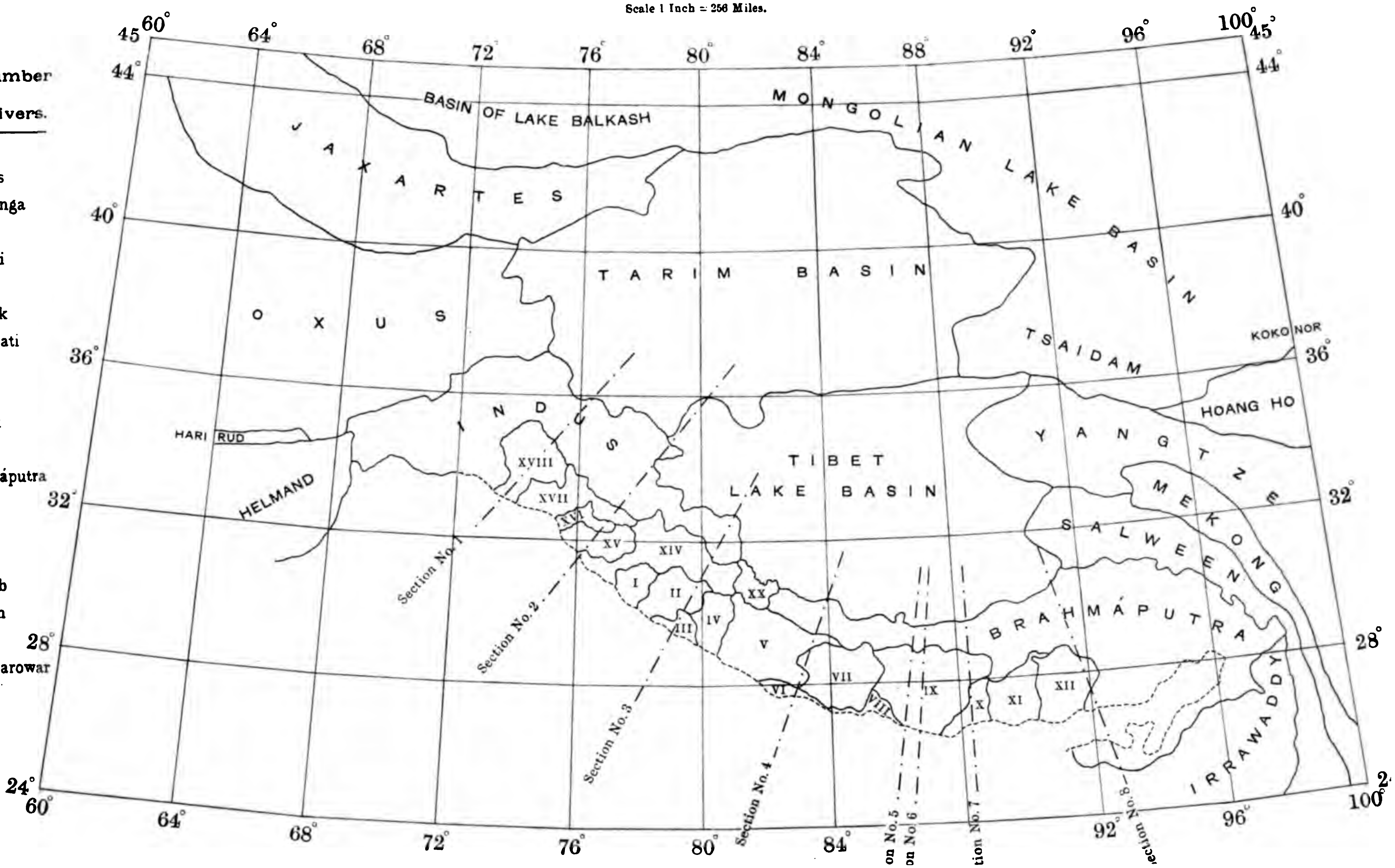
INDEX CHART

showing CATCHMENT AREAS of the HIMALAYAN and TRANS-HIMALAYAN RIVERS and LAKES.

Scale 1 Inch = 256 Miles.

Reference Number to Himalayan Rivers.

I	Jumna
II	Ganges
III	Rámganga
IV	Káli
V	Karnáli
VI	Rápti
VII	Gandak
VIII	Bághmati
IX	Kosi
X	Tista
XI	Ráidak
XII	Manás
XIII	Brahmáputra
XIV	Sutlej
XV	Beás
XVI	Rávi
XVII	Chenáb
XVIII	Jhelum
XIX	Indus
XX	Manásarowar



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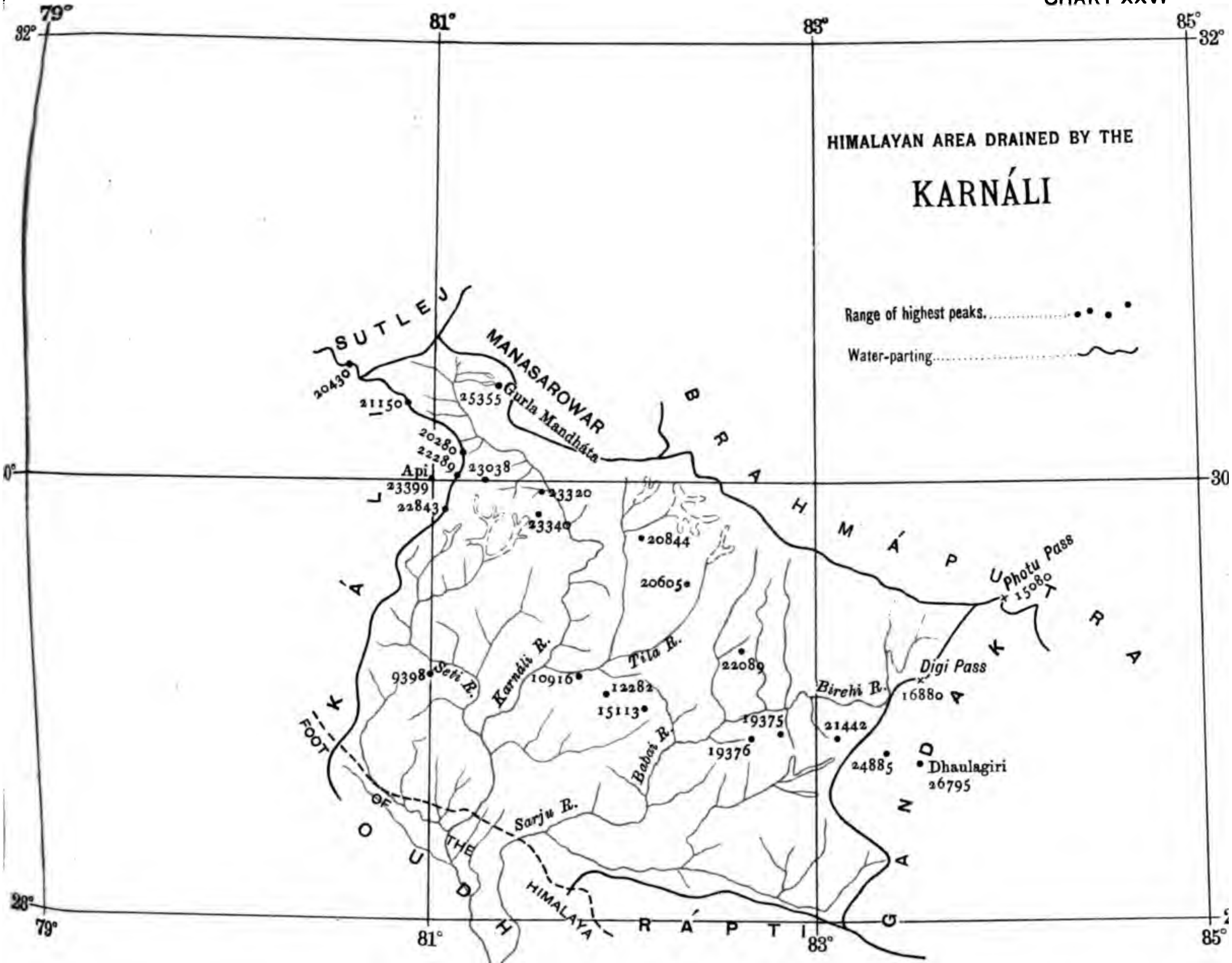
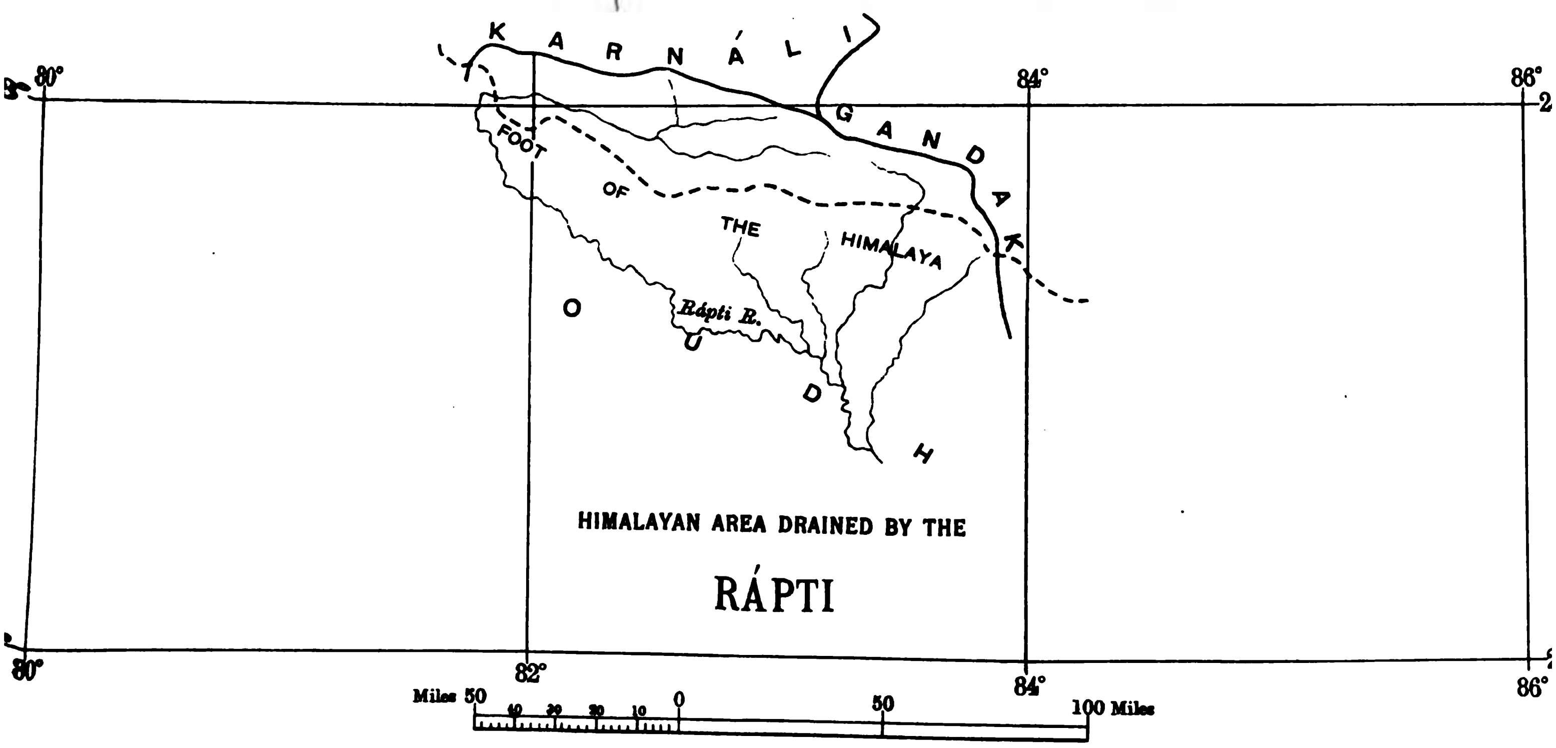

HIMALAYAN AREA DRAINED BY THE
KARNÁLI
Range of highest peaks
Water-parting
SUTLEJ
MANASAROWAR
BRAHMÁPUTRA
KÁLI
GANDAK
FOOT OF THE HIMALAYA
OUDH
RÁPTI
Gurla Mandháta
25355
Api
23399
22843
20430
21150
20280
22289
23038
23320
23340
20844
20605
Photu Pass
15080
Digi Pass
16880
Tila R.
Karnáli R.
Seti R.
Birehi R.
Babai R.
Sarju R.
9398
10916
12282
15113
22089
19375
19376
21442
24885
Dhaulagiri
26795
79°
81°
83°
85°
32°
30°
28°


KARNÁLI
GANDAK
FOOT OF THE HIMALAYA
OUDH
Rápti R.
HIMALAYAN AREA DRAINED BY THE
RÁPTI
80°
82°
84°
86°
Miles 50 40 30 20 10 0 50 100 Miles

* Zaskar is the form of spelling adopted in the Imperial Gazetteer. Mr. Hayden writes "Ladakhis pronounce the "name Zangskar, Central Tibetans pronounce it Zangkar, Kashmiris pronounce it Zaskar."

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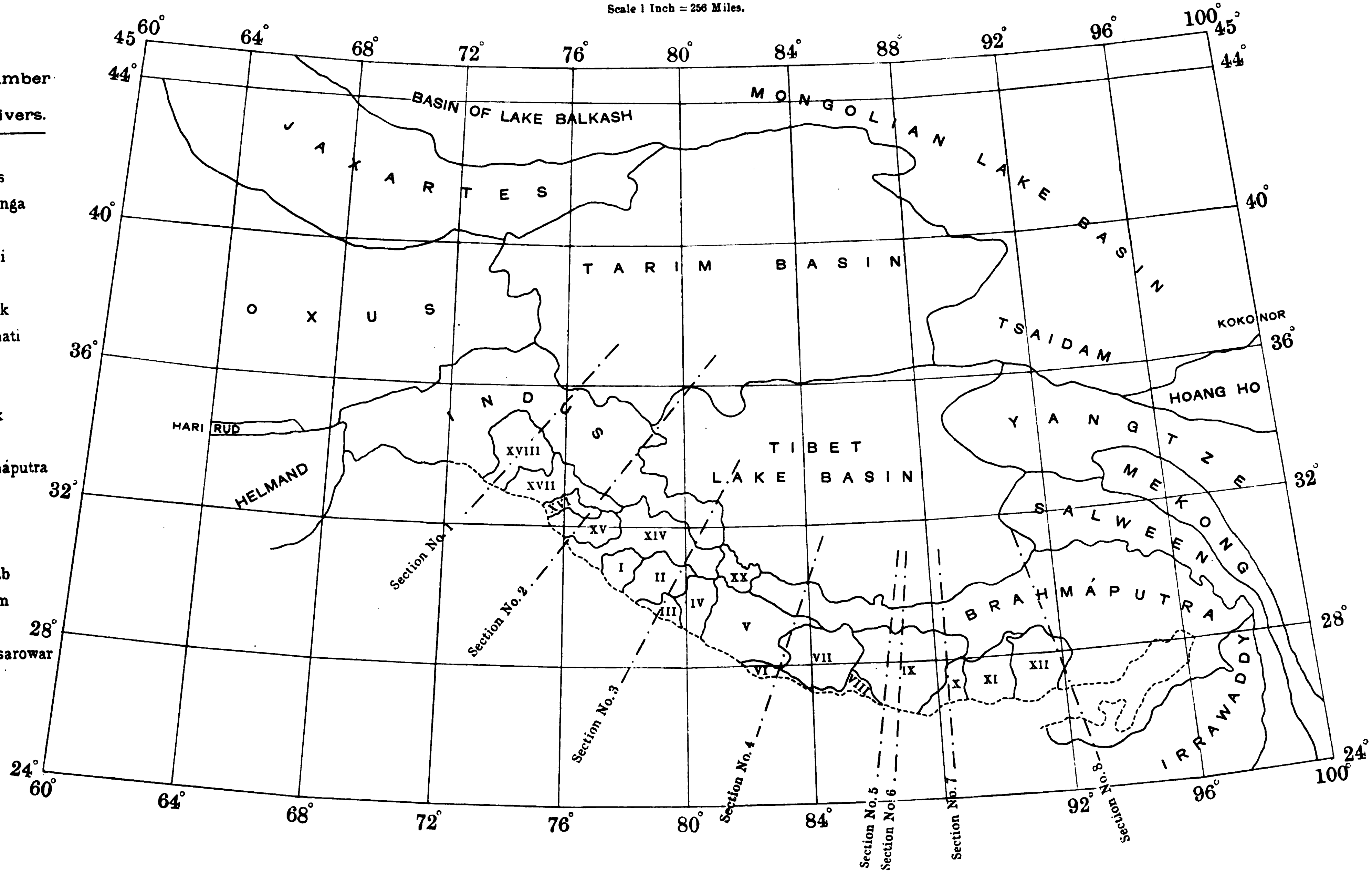

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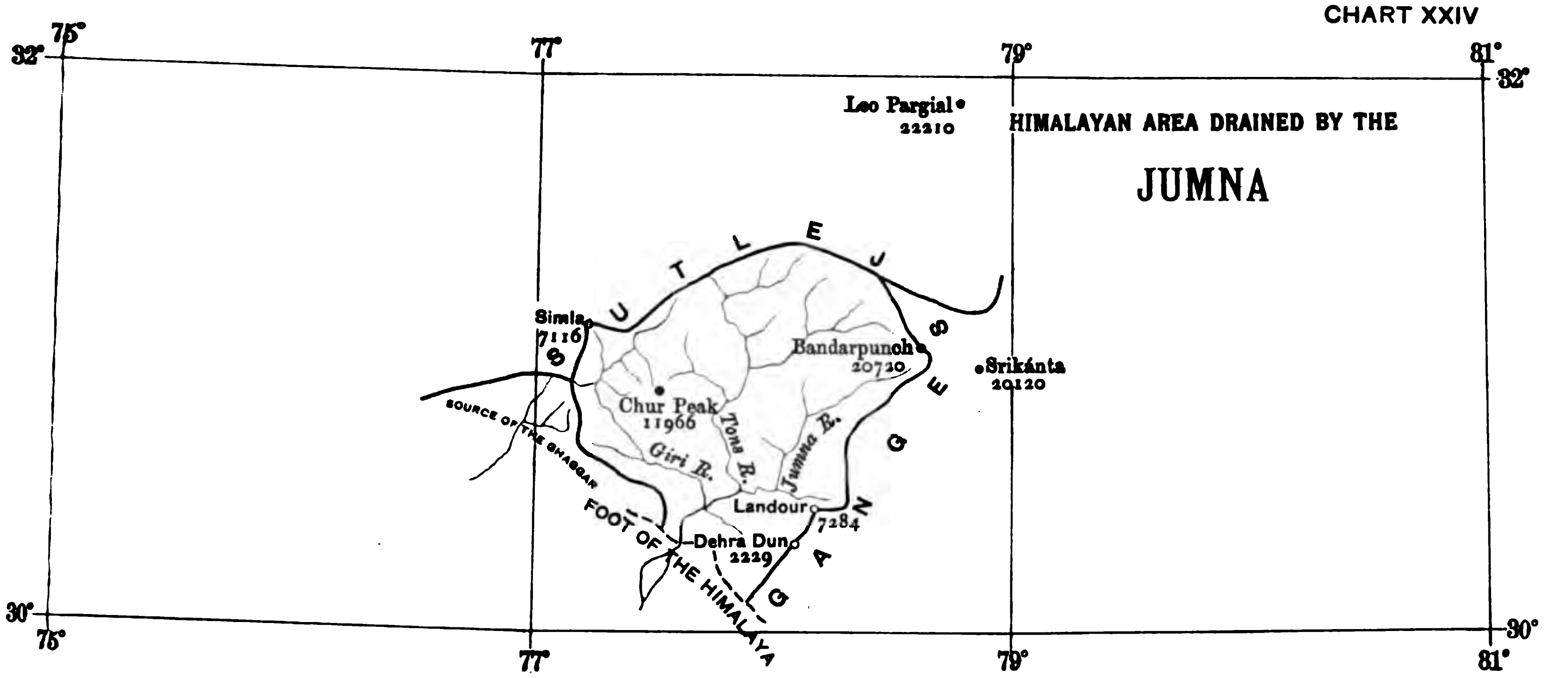
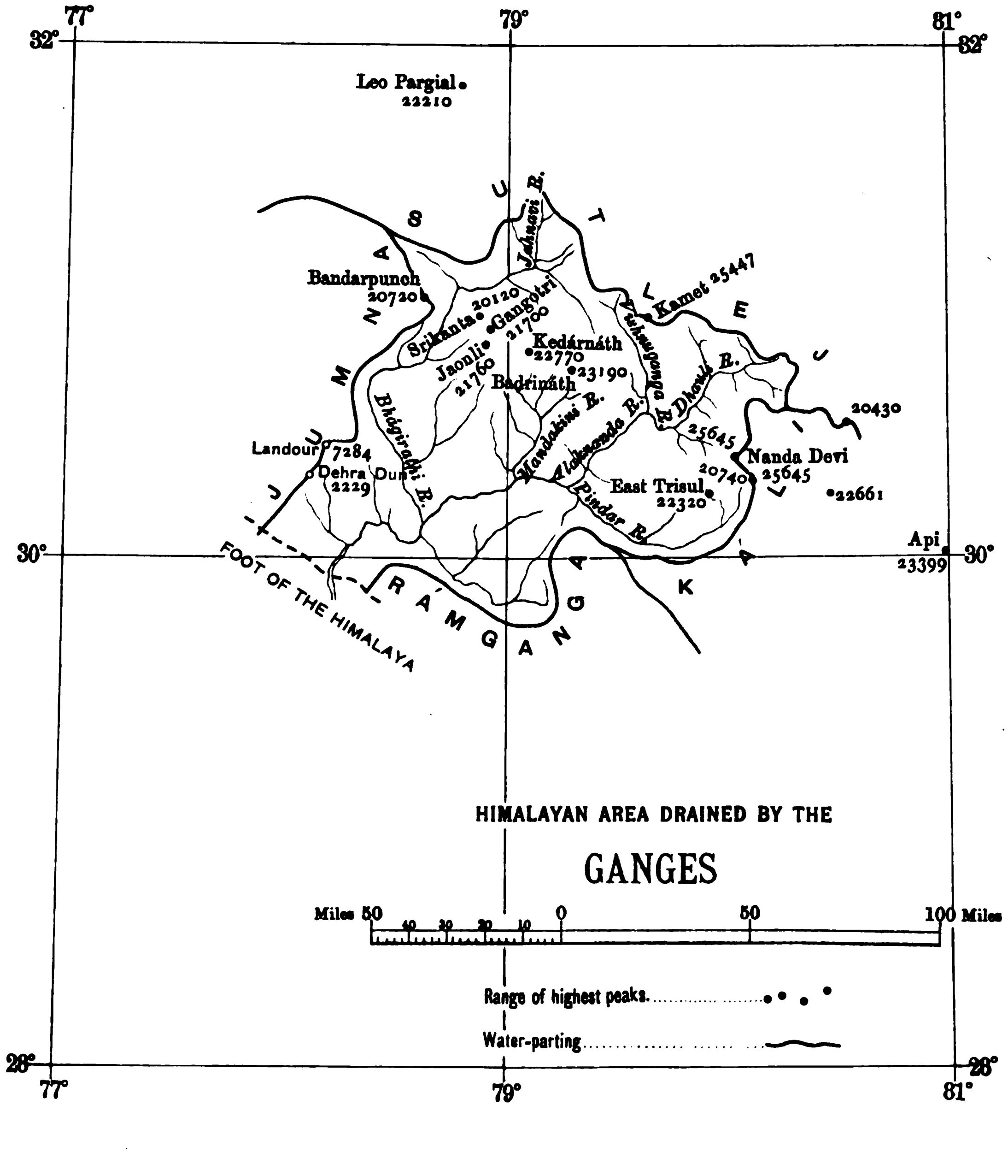
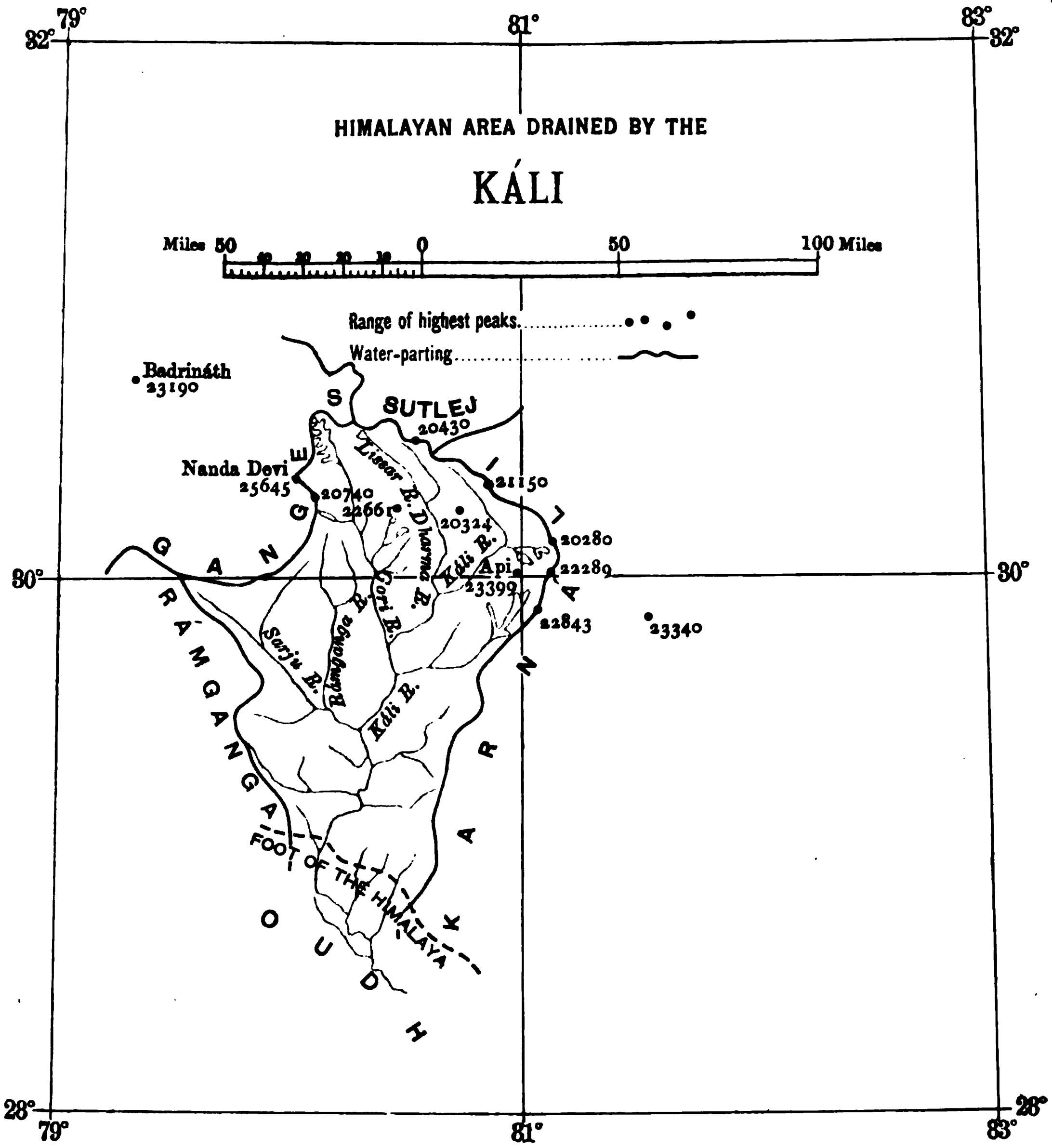
XII	Manás
XIII	Brahmáputra
XIV	Sutlej
XV	Beás
XVI	Rávi
XVII	Chenáb
XVIII	Jhelum
XIX	Indus
XX	Manásarowar

CHART XXIV


HIMALAYAN AREA DRAINED BY THE
JUMNA
Leo Pargial 22210
Simla 7116
Bandarpunch 20720
Srikánta 20120
Chur Peak 11966
Tons R.
Jumna R.
Giri R.
Landour 7284
Dehra Dun 2229
SOURCE OF THE GHAGGAR
FOOT OF THE HIMALAYA
SUTLEJ
GANGES


HIMALAYAN AREA DRAINED BY THE
GANGES
Leo Pargial 22210
Bandarpunch 20720
Srikánta 20120
Gangotri 21700
Jaonli 21760
Kedárnáth 22770
23190
Badrináth
Kamet 25447
Jahnavi R.
Bhágirathi R.
Mandakini R.
Alaknanda R.
Dhauli R.
Pindar R.
25645
Nanda Devi 25645
20740
East Trisul 22320
22661
20430
Gurla Mandháta 25355
Api 23399
Landour 7284
Dehra Dun 2229
FOOT OF THE HIMALAYA
SUTLEJ
JUMNA
RÁMGANGA
KÁLI
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water-parting


HIMALAYAN AREA DRAINED BY THE
KÁLI
Miles 50
0
50
100 Miles
Range of highest peaks
Water-parting
Badrináth 23190
SUTLEJ
20430
Nanda Devi 25645
20740
22661
20324
21150
20280
22289
Api 23399
22843
23340
GANGES
RÁMGANGA
Lissar R.
Dharma R.
Káli R.
Gori R.
Rámganga R.
Sarju R.
Káli R.
NÁRKANTAI
FOOT OF THE HIMALAYA
OUDH
79°
81°
83°
82°
80°
28°

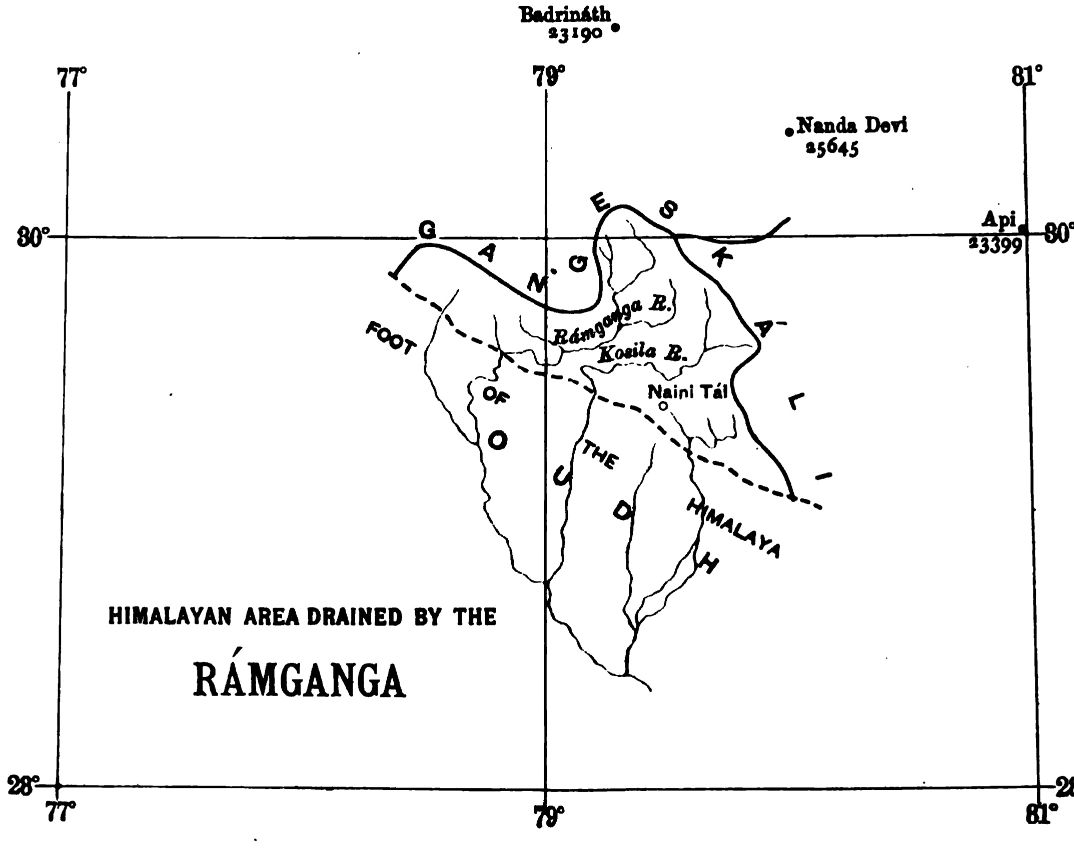
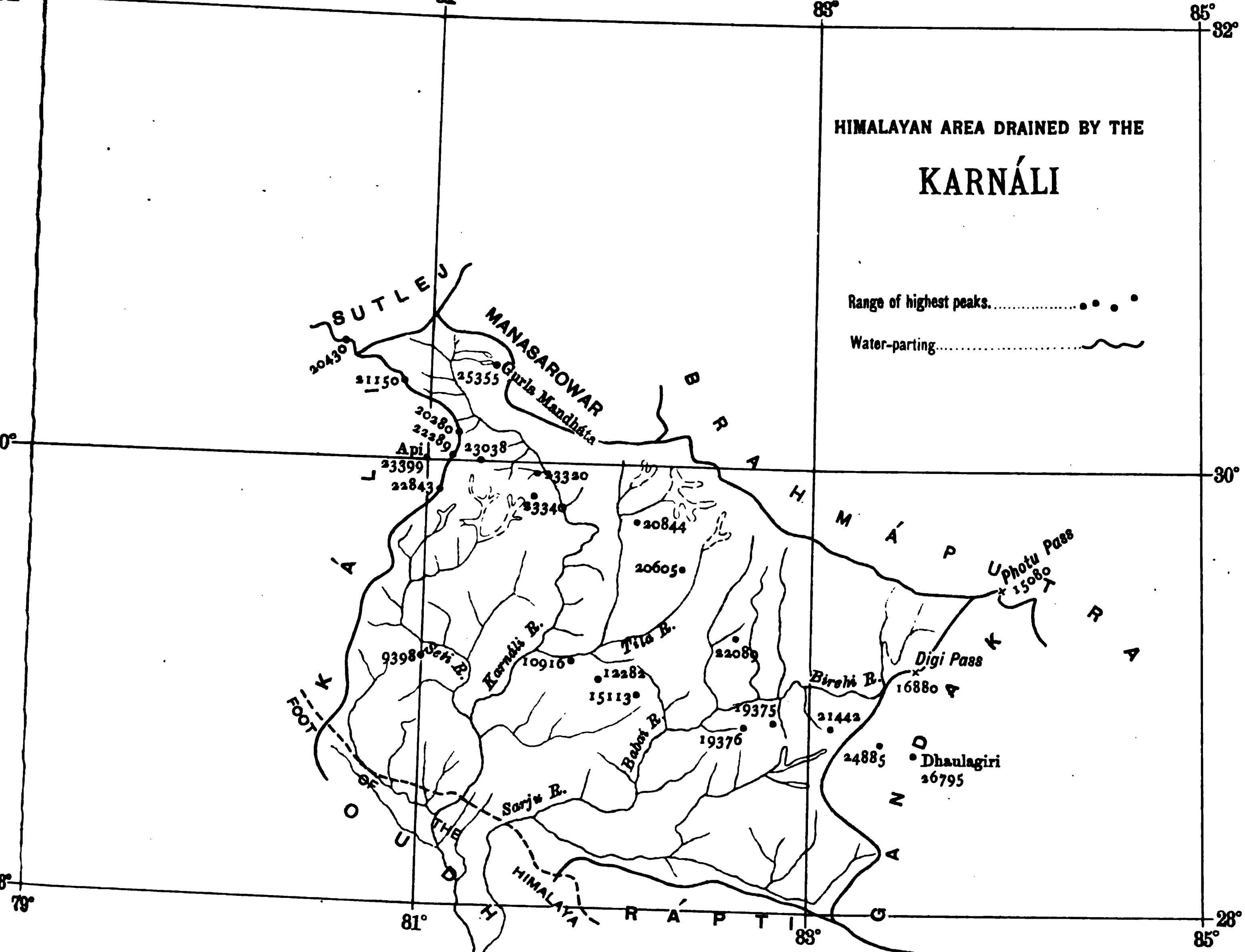

Badrináth 23190
Nanda Devi 25645
Api 23399
GANGES
KÁLI
Rámganga R.
Kosila R.
Naini Tál
FOOT OF THE HIMALAYA
OUDH
HIMALAYAN AREA DRAINED BY THE
RÁMGANGA
77°
79°
81°
80°
28°

CHART XXVI


HIMALAYAN AREA DRAINED BY THE
KARNÁLI
Range of highest peaks
Water-parting
SUTLEJ
MANASAROWAR
BRAHMÁPUTRA
KÁLI
Gurla Mandhāta
25355
20430
21150
20280
22289
Api
23399
22843
23038
23320
23340
20844
20605
Photu Pass
15080
Digi Pass
16880
Birehi R.
21442
24885
Dhaulagiri
26795
22080
19375
19376
Tila R.
Karnali R.
Seti R.
9398
10916
12282
15113
Babai R.
Sarju R.
FOOT OF THE HIMALAYA
OUDH
RÁPTI
GANDAK

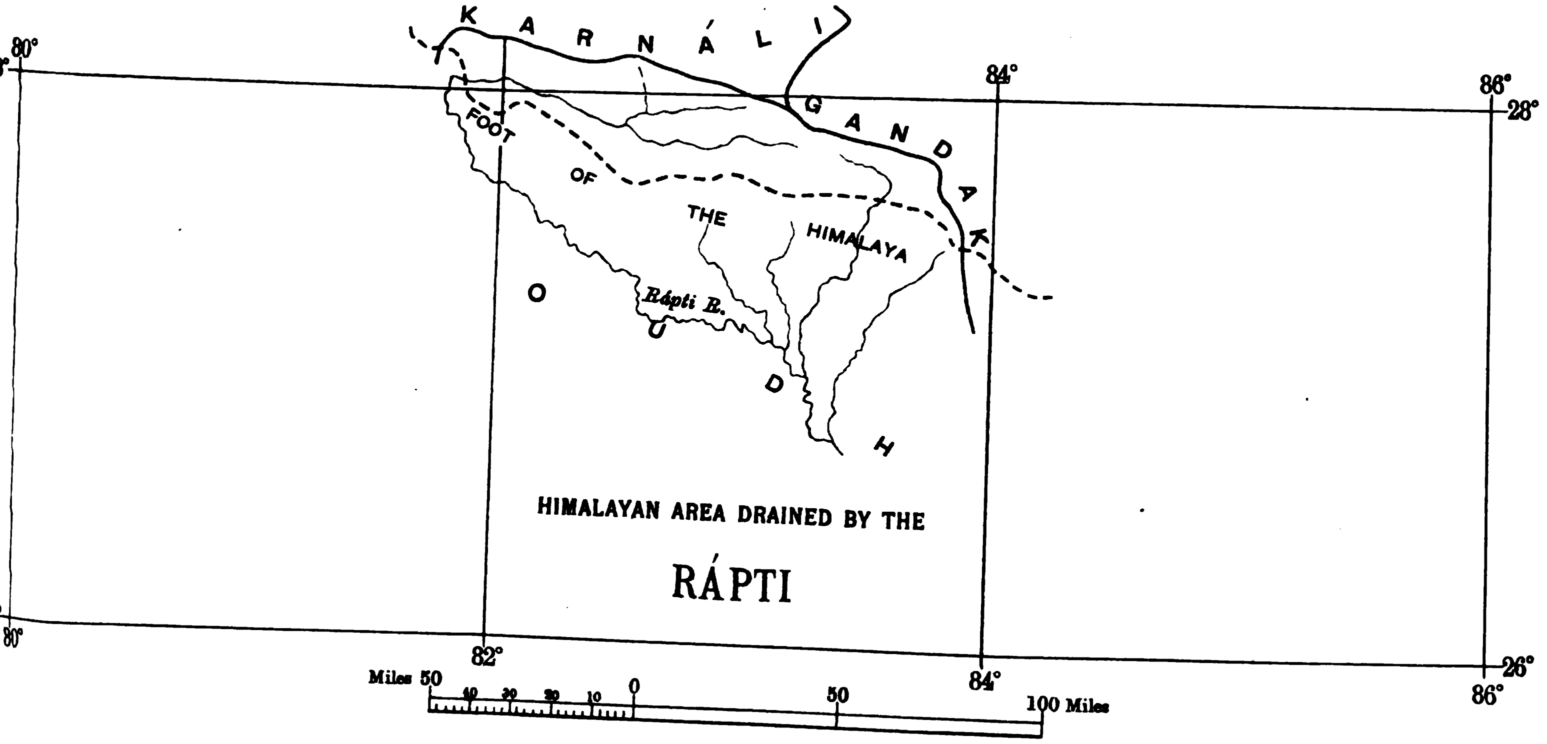
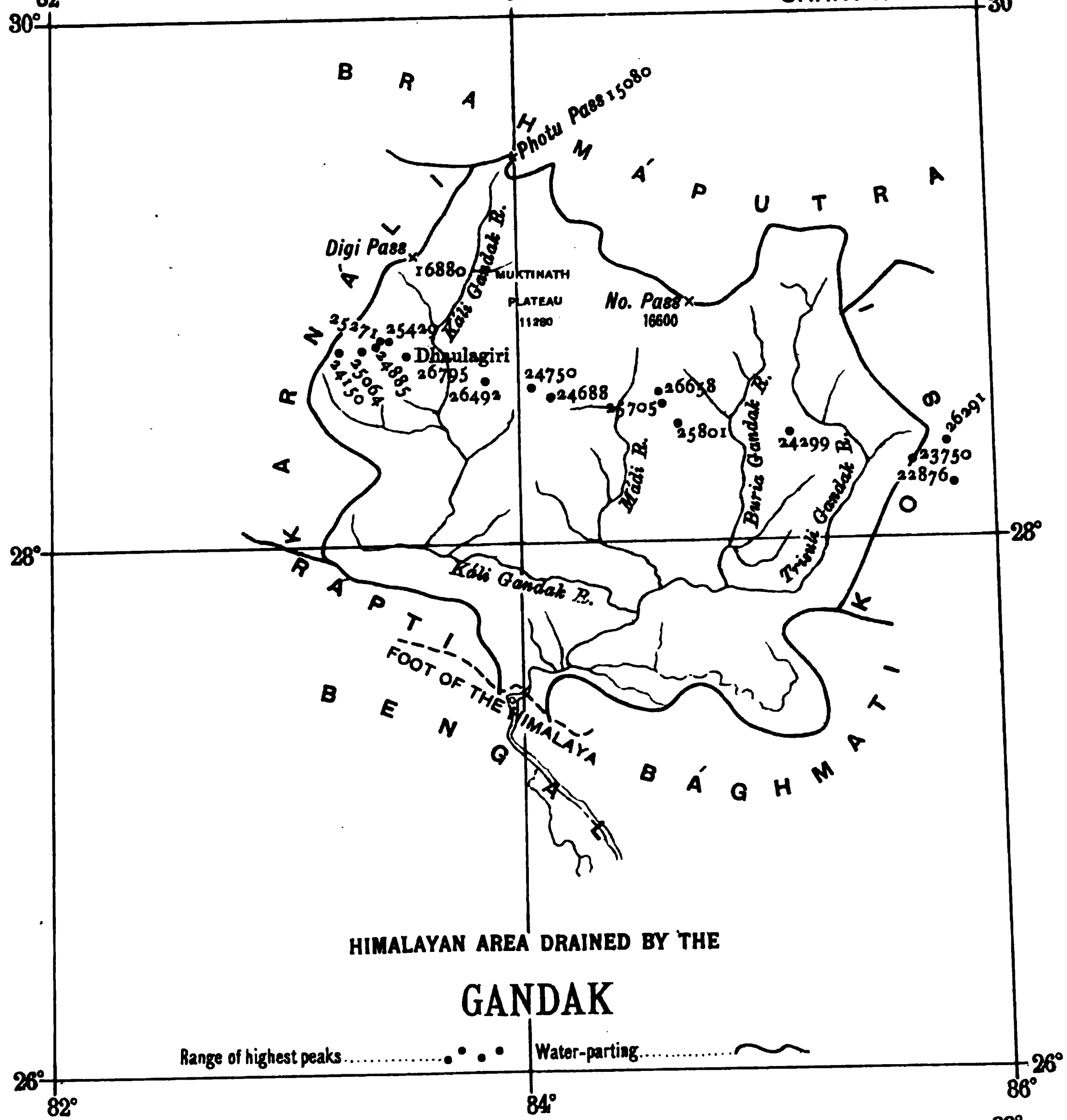
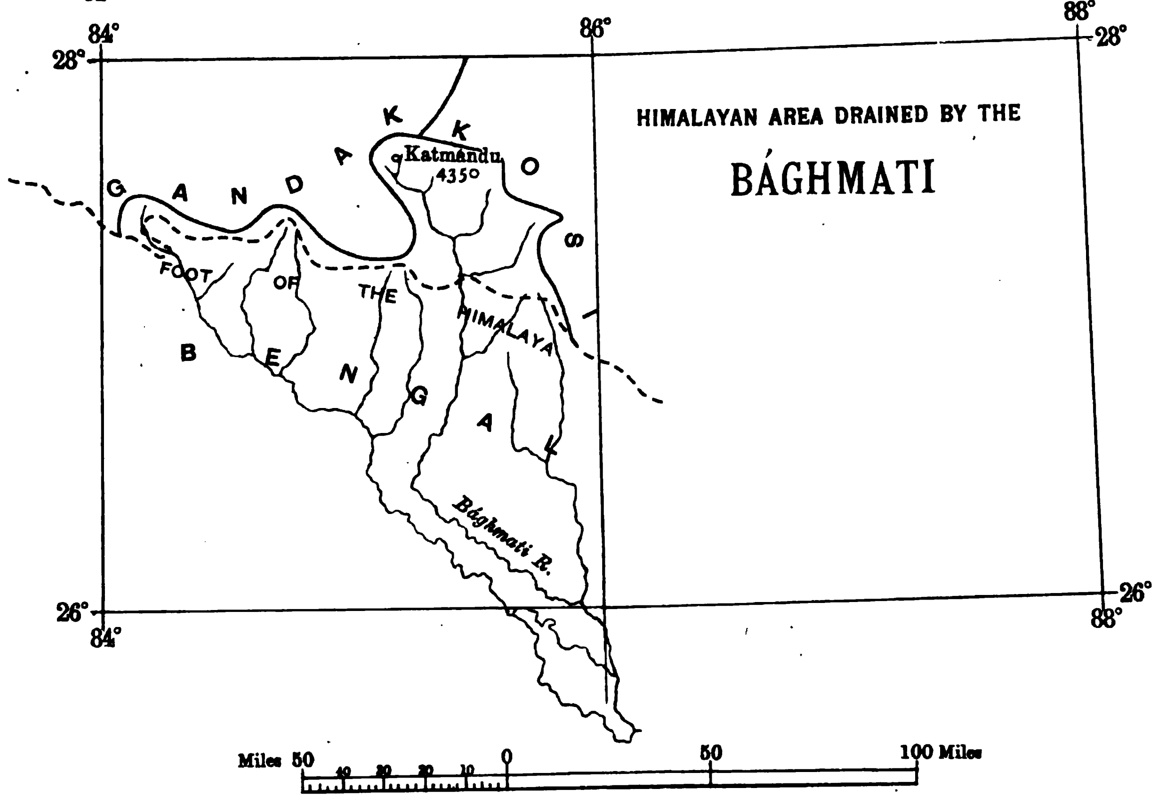

KARNÁLI
GANDAK
FOOT OF THE HIMALAYA
OUDH
Rápti R.
HIMALAYAN AREA DRAINED BY THE
RÁPTI
Miles 50
100 Miles

CHART XXVII



HIMALAYAN AREA DRAINED BY THE

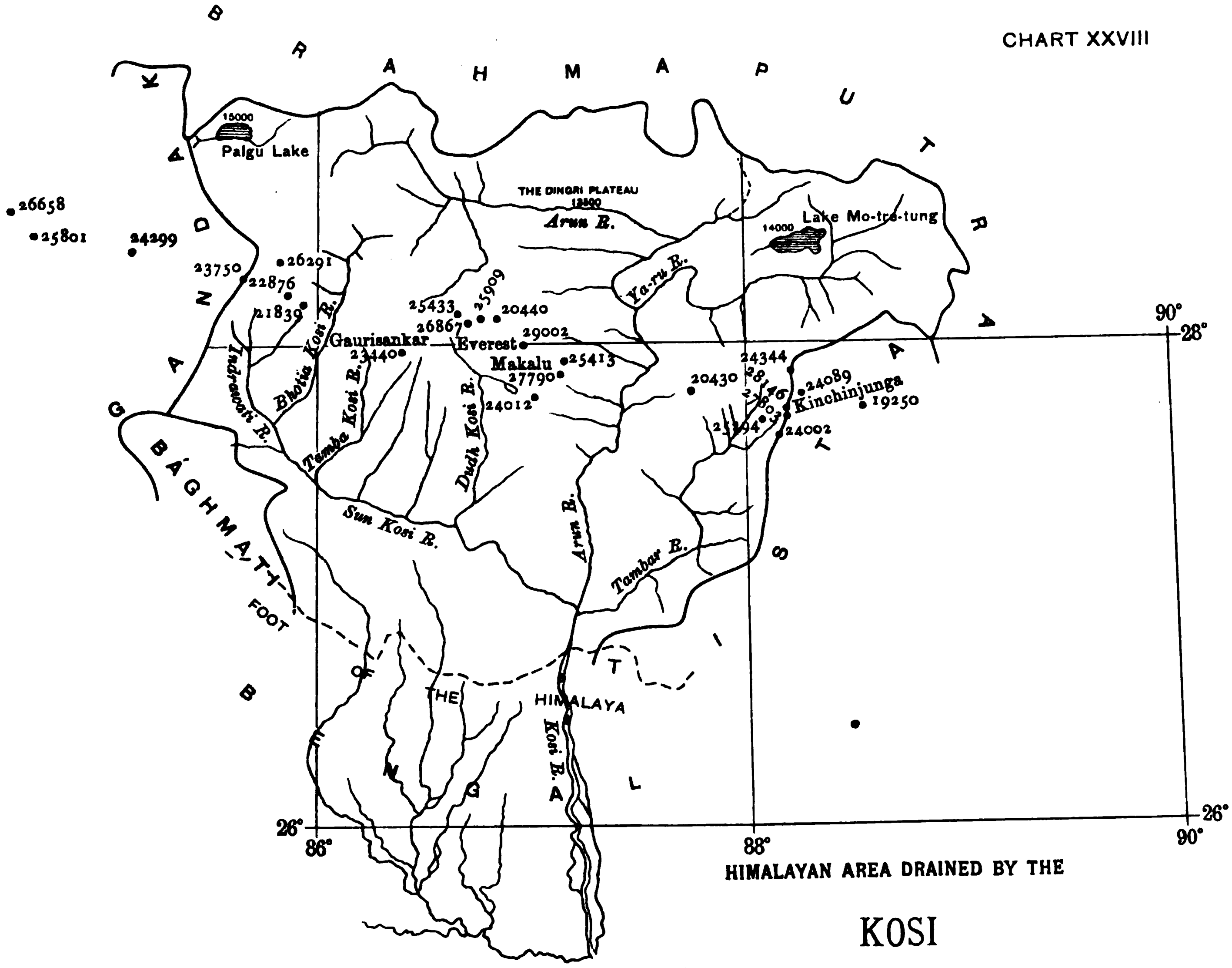
GANDAK



HIMALAYAN AREA DRAINED BY THE

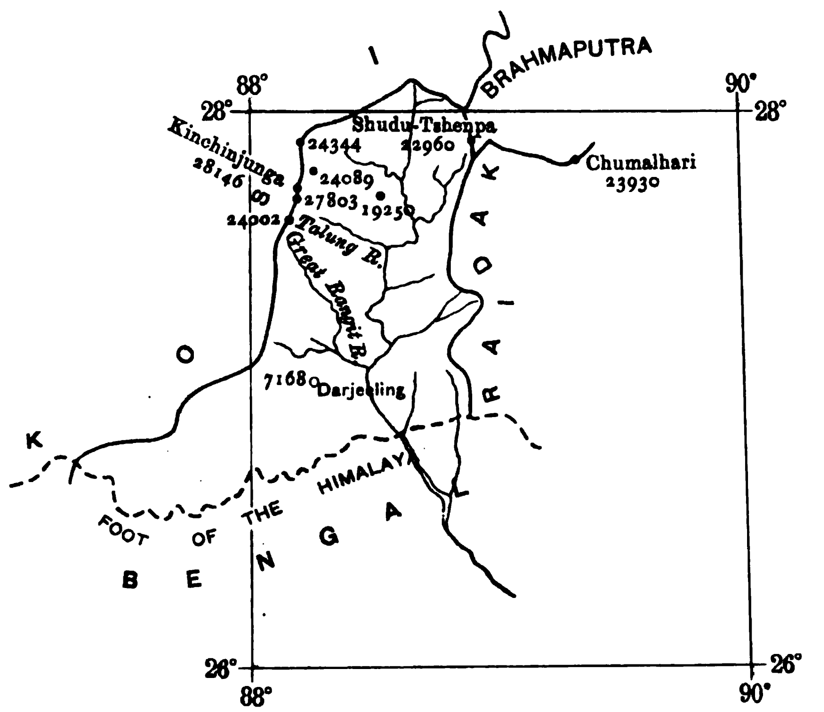
BÁGHMATI

CHART XXVIII



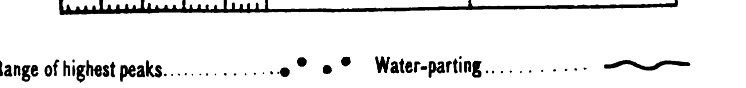
HIMALAYAN AREA DRAINED BY THE

KOSI



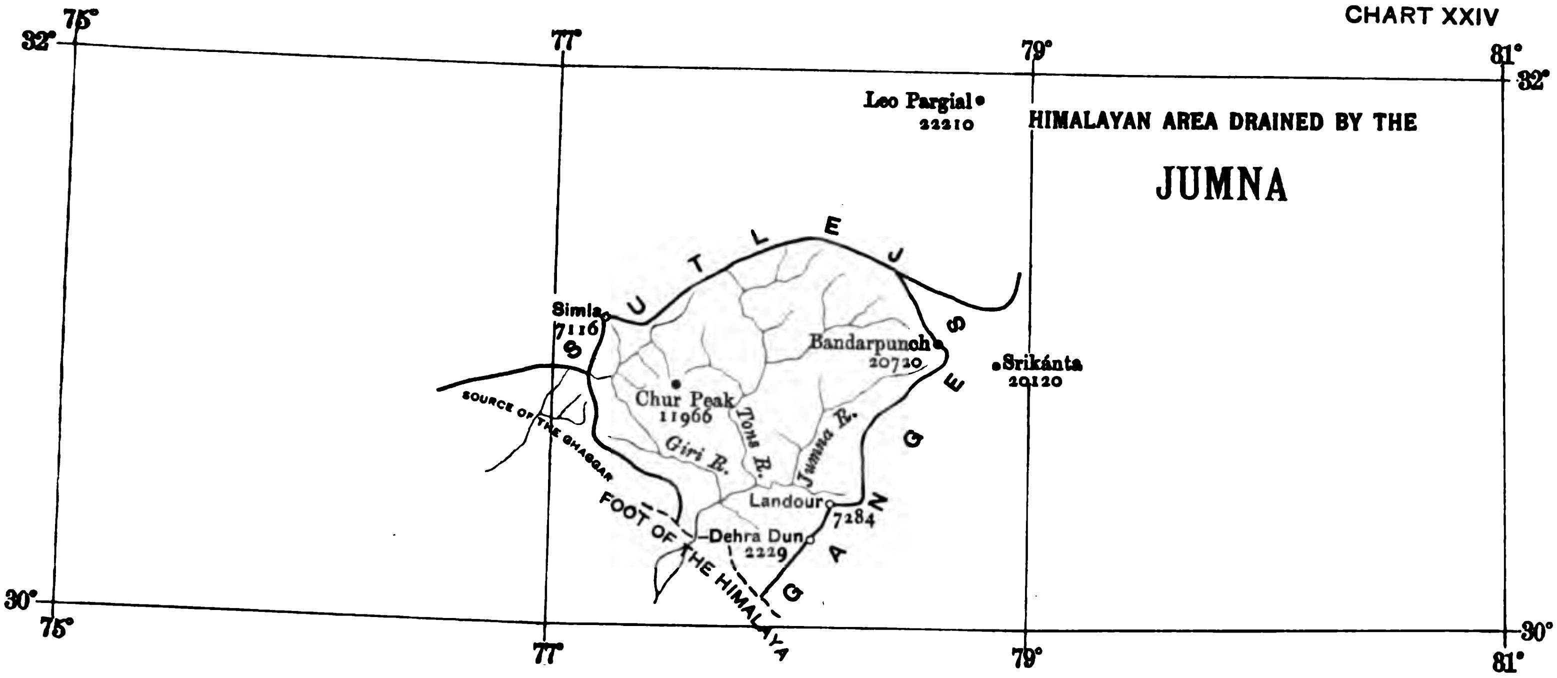
HIMALAYAN AREA DRAINED BY THE

TISTA

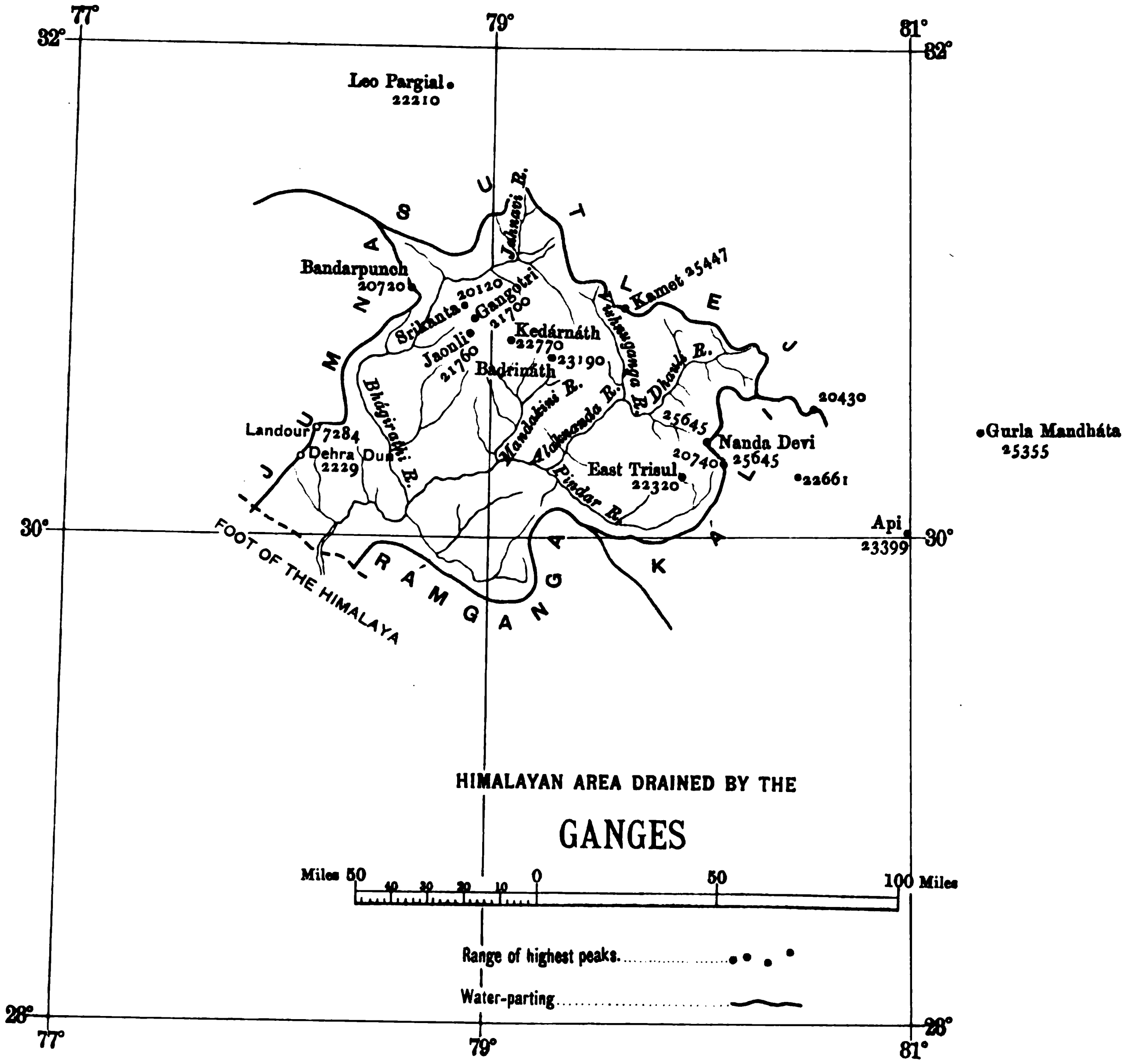


Range of highest peaks.............. • • • Water-parting...........

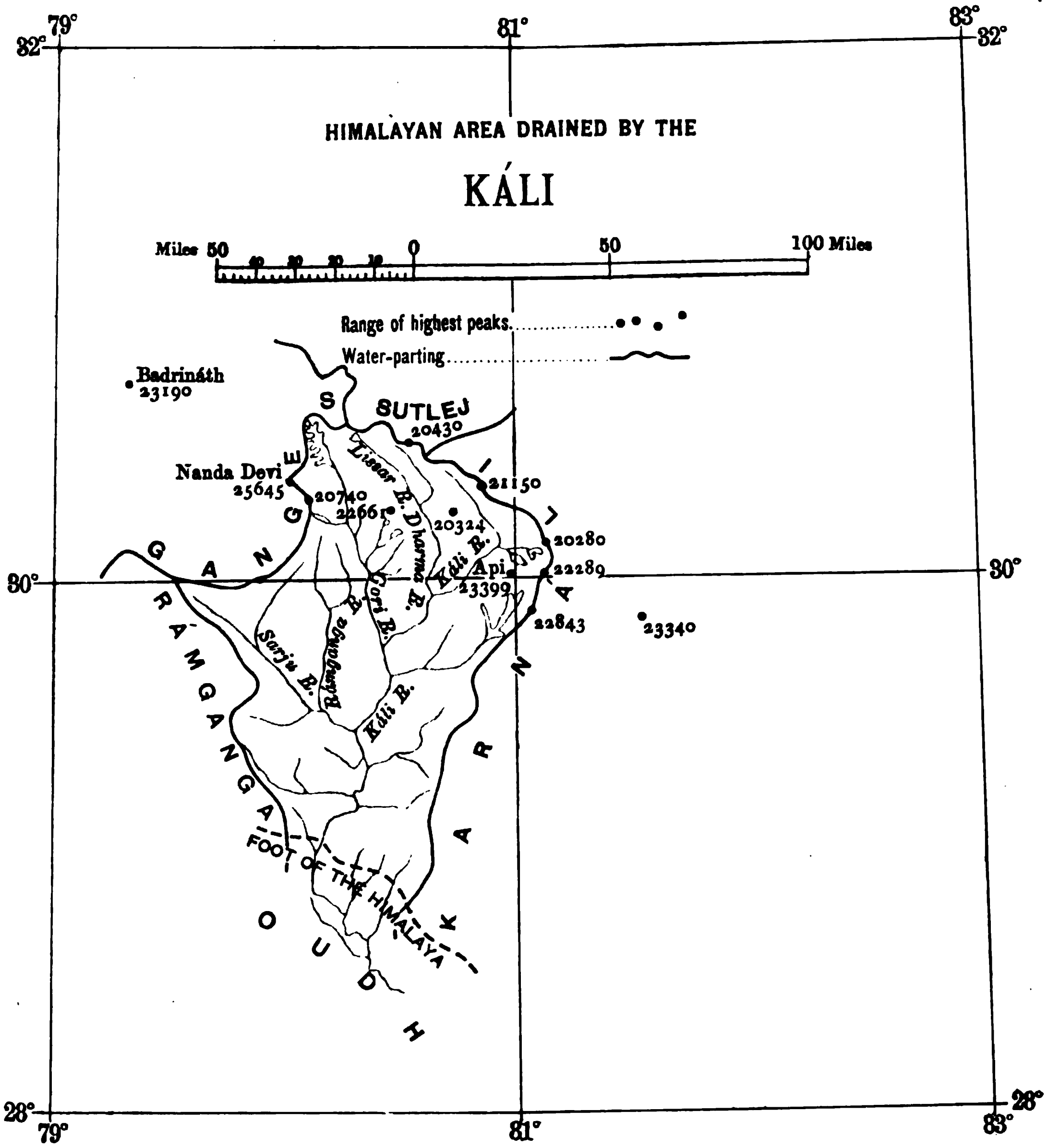
CHART XXIV



HIMALAYAN AREA DRAINED BY THE
JUMNA
75°
77°
79°
81°
32°
30°
Leo Pargial
22210
Simla
7116
Bandarpunch
20720
Srikánta
20120
Chur Peak
11966
Giri R.
Tons R.
Jumna R.
Landour
7284
Dehra Dun
2229
SUTLEJ
GANGES
SOURCE OF THE GHAGGAR
FOOT OF THE HIMALAYA



HIMALAYAN AREA DRAINED BY THE
GANGES
77°
79°
81°
32°
30°
28°
Leo Pargial
22210
SUTLEJ
JUMNA
Jahnavi R.
Bandarpunch
20720
Srikánta
20120
Gangotri
21700
Jaonli
21760
Kedárnáth
22770
23190
Badrináth
Kamet 25447
Vishnuganga R.
Dhauli R.
Bhágirathi R.
Mandakini R.
Alaknanda R.
Pindar R.
20430
25645
Nanda Devi
20740
25645
East Trisul
22320
22661
Gurla Mandháta
25355
Api
23399
Landour
7284
Dehra Dun
2229
RÁMGANGA
KALI
FOOT OF THE HIMALAYA
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water-parting


HIMALAYAN AREA DRAINED BY THE
KÁLI
Miles 50 40 30 20 10 0 50 100 Miles
Range of highest peaks
Water-parting
Badrináth 23190
SUTLEJ
Nanda Devi 25645
20430
21150
20740
22661
20324
20280
Api 23399
22289
22843
23340
Lissar R.
Dharma R.
Káli R.
Gori R.
Rámganga R.
Sarju R.
GANGES
RÁMGANGA
KARNALI
FOOT OF THE HIMALAYA
OUDH
79°
81°
83°
82°
80°
28°

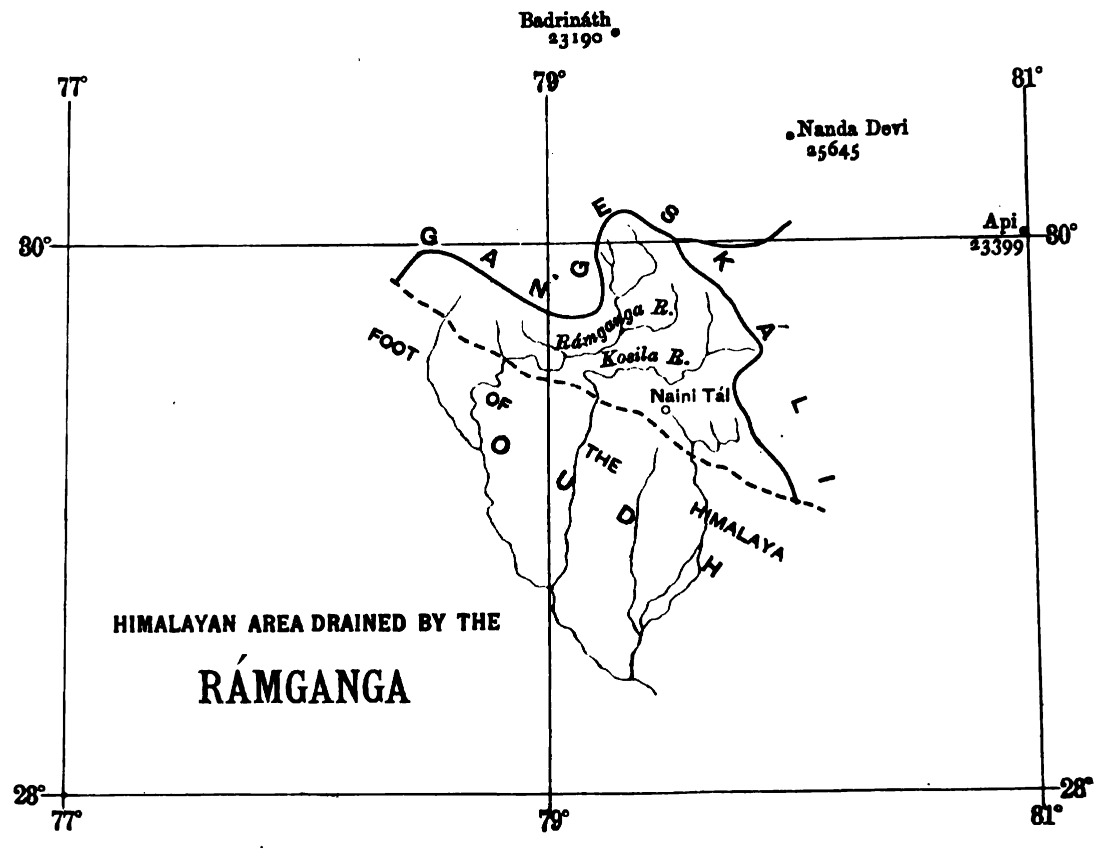
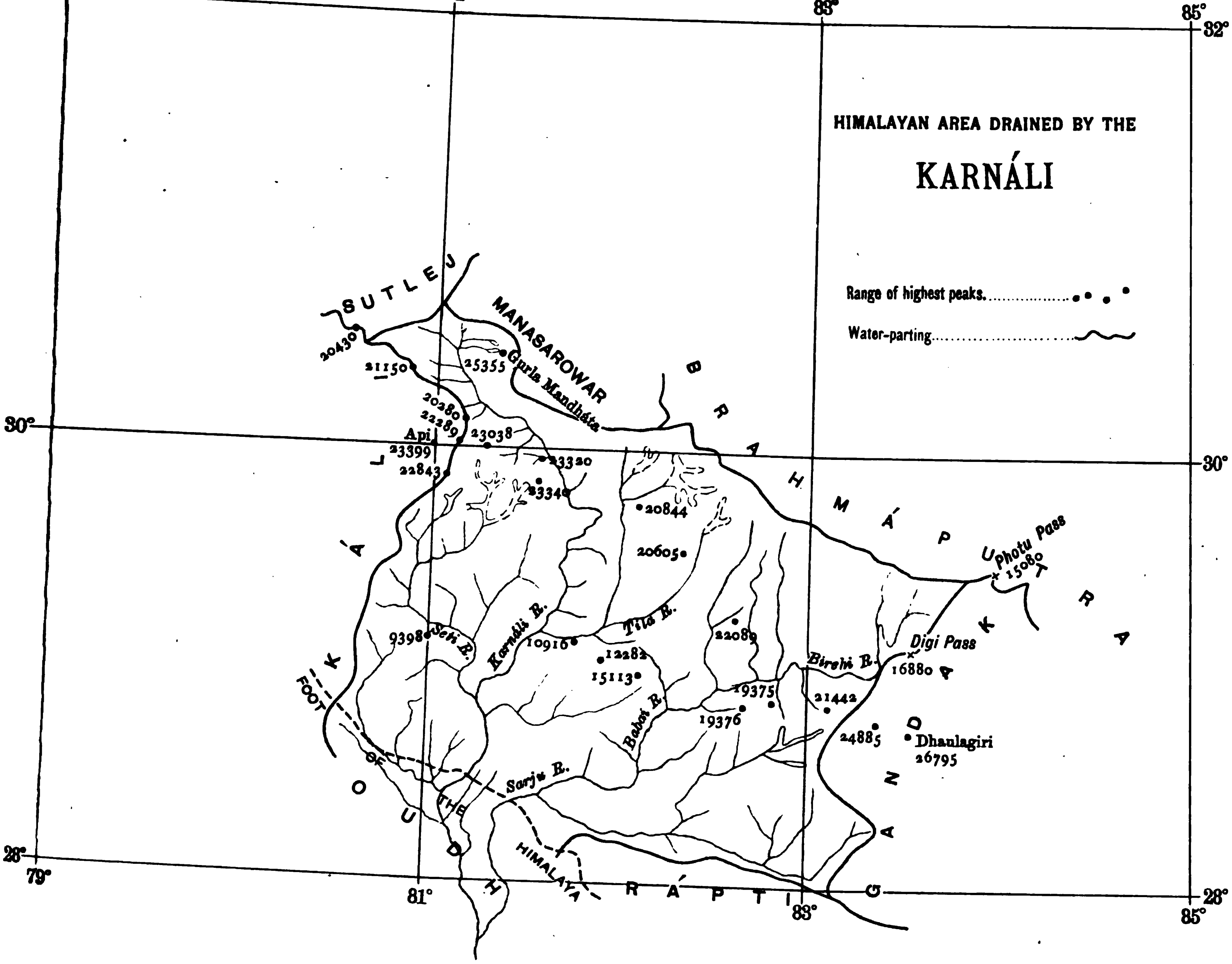

Badrináth 23190
Nanda Devi 25645
Api 23399
GANGES
KALI
Rámganga R.
Kosila R.
Naini Tál
FOOT OF THE HIMALAYA
OUDH
HIMALAYAN AREA DRAINED BY THE
RÁMGANGA
77°
79°
81°
80°
28°

CHART XXVI


HIMALAYAN AREA DRAINED BY THE
KARNÁLI
Range of highest peaks
Water-parting
SUTLEJ
MANASAROWAR
BRAHMÁPUTRA
Gurla Mandhata
25355
20430
21150
20280
22289
Api
23399
22843
23038
23320
23340
20844
20605
Photu Pass
15080
Digi Pass
16880
Karnáli R.
Seti R.
Tila R.
Birehi R.
Babai R.
Sarju R.
9398
10916
12282
15113
22089
19375
19376
21442
24885
Dhaulagiri
26795
KÁLI
GANDAK
FOOT OF THE HIMALAYA
OUDH
RÁPTI
32°
30°
28°
79°
81°
83°
85°

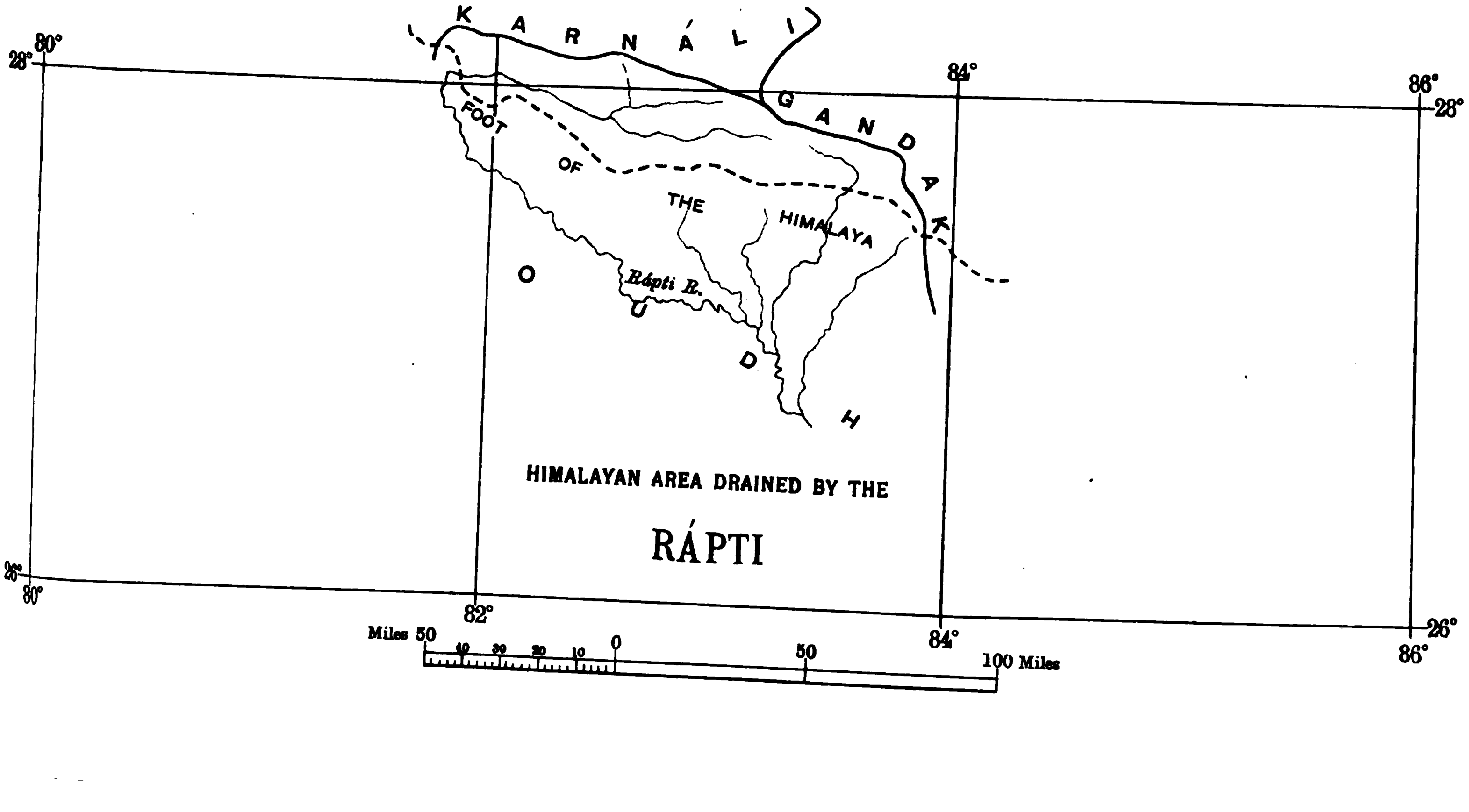
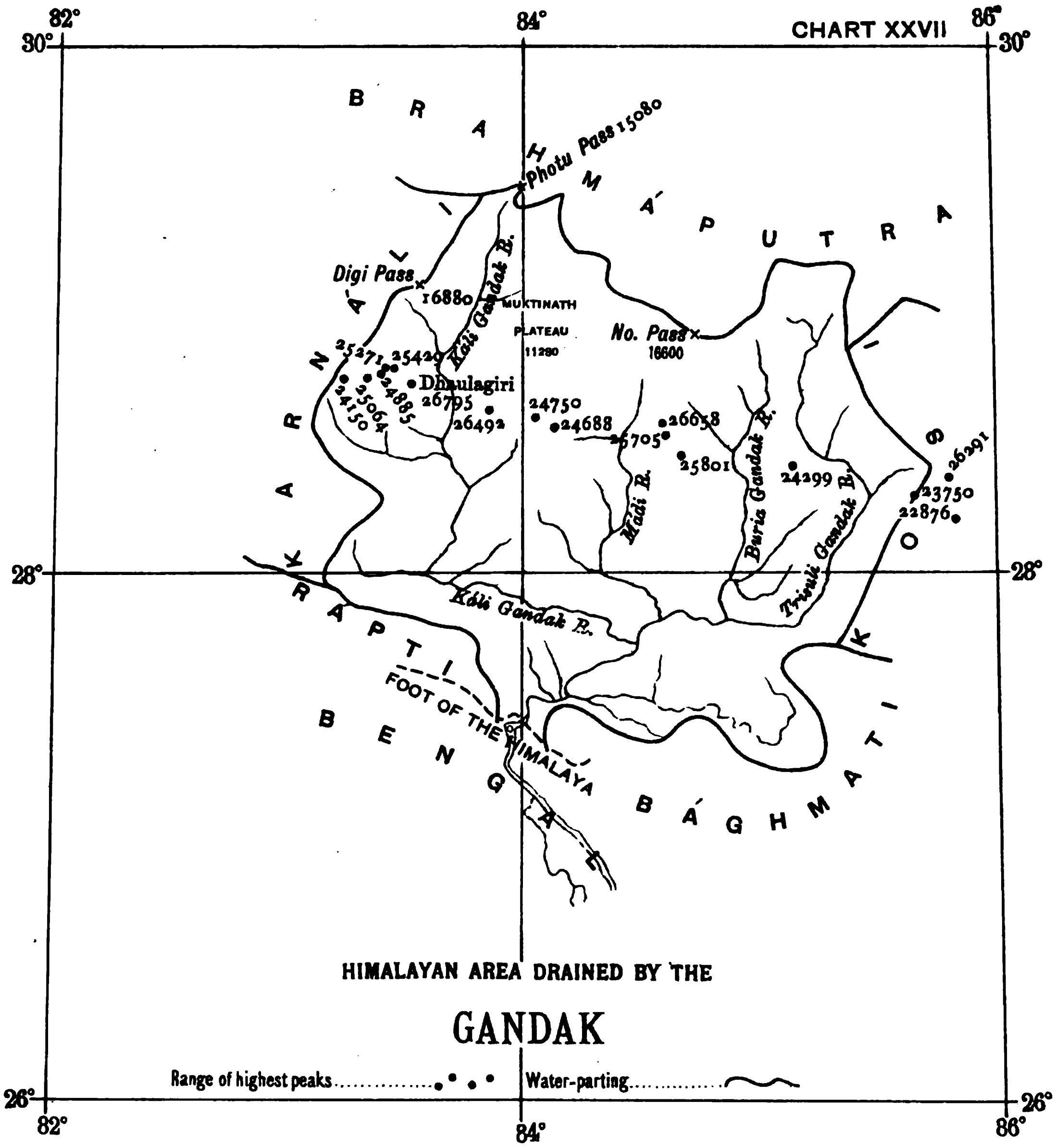
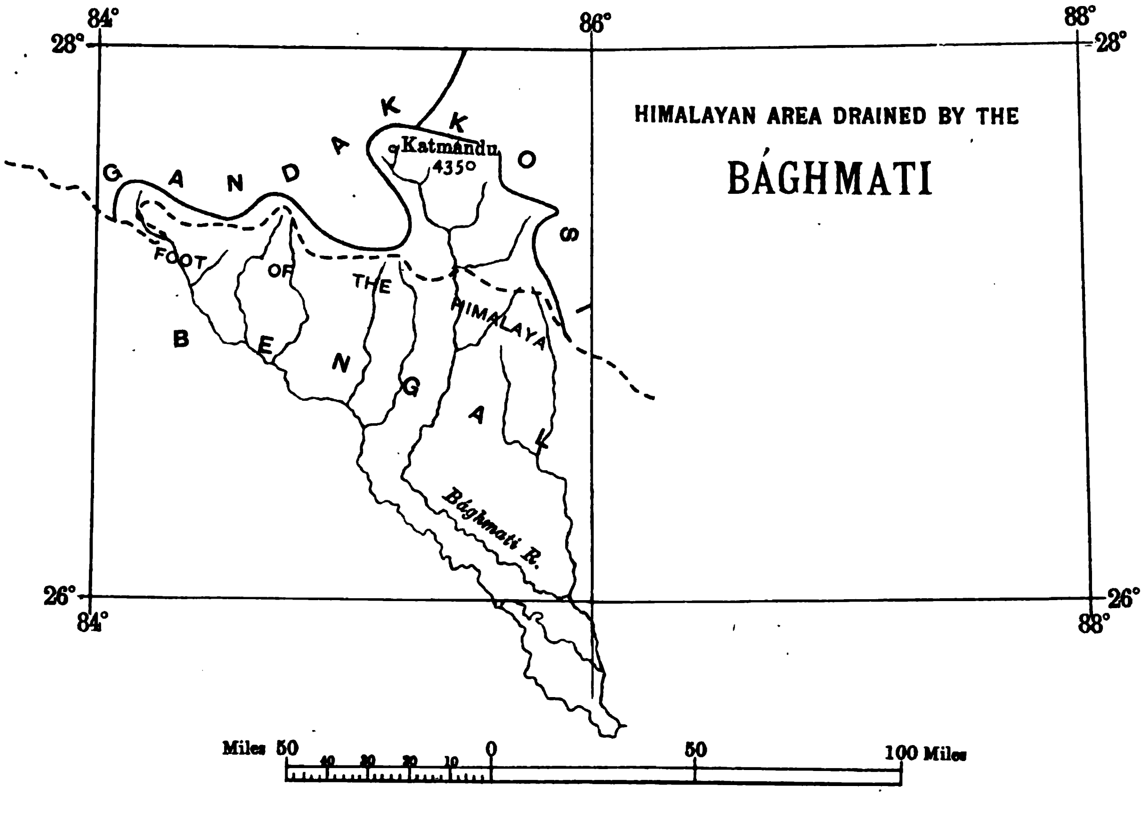

KARNÁLI
GANDAK
FOOT OF THE HIMALAYA
OUDH
Rápti R.
HIMALAYAN AREA DRAINED BY THE
RÁPTI
Miles 50 40 30 20 10 0 50 100 Miles
28°
26°
80°
82°
84°
86°

CHART XXVII



HIMALAYAN AREA DRAINED BY THE

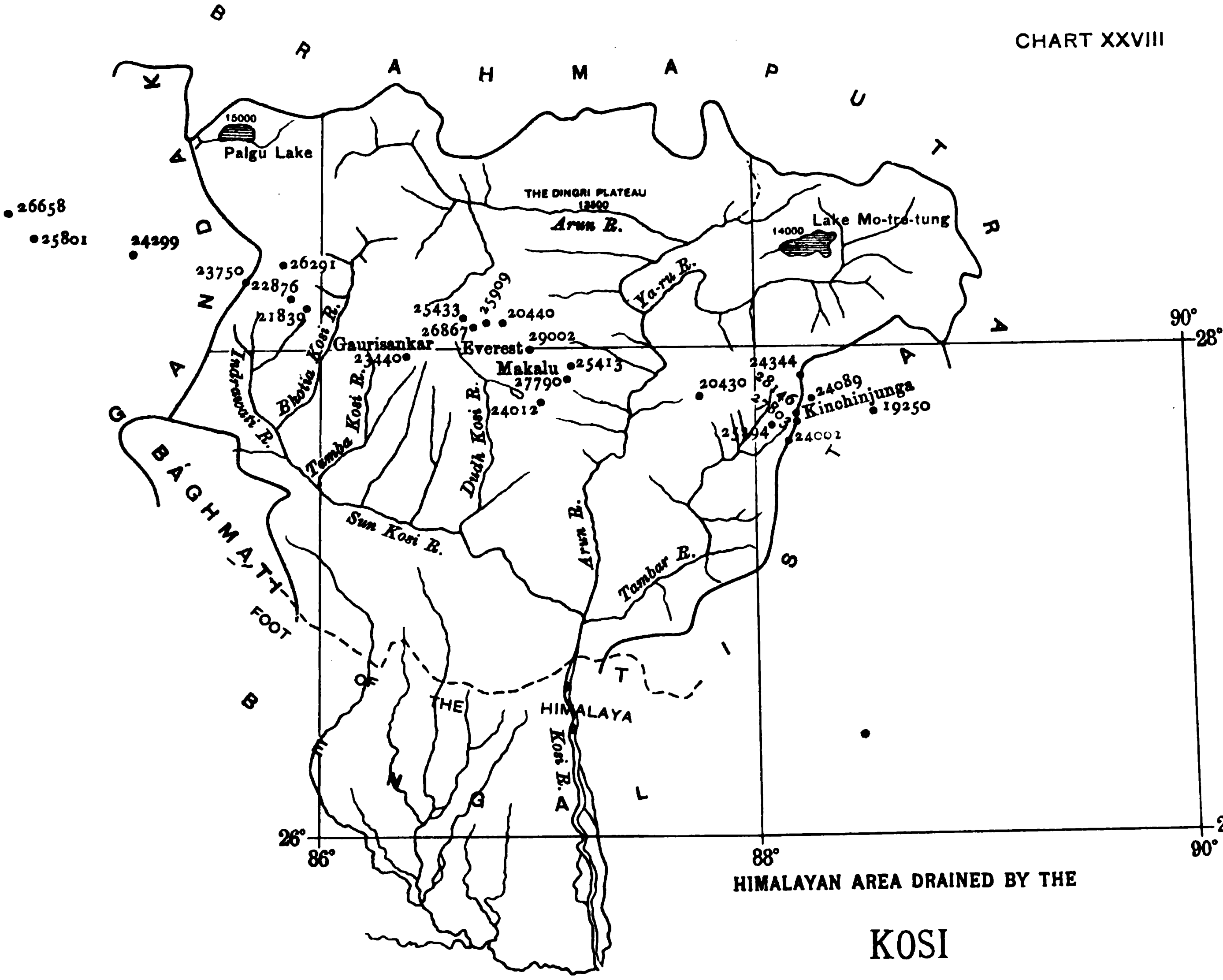
GANDAK



HIMALAYAN AREA DRAINED BY THE

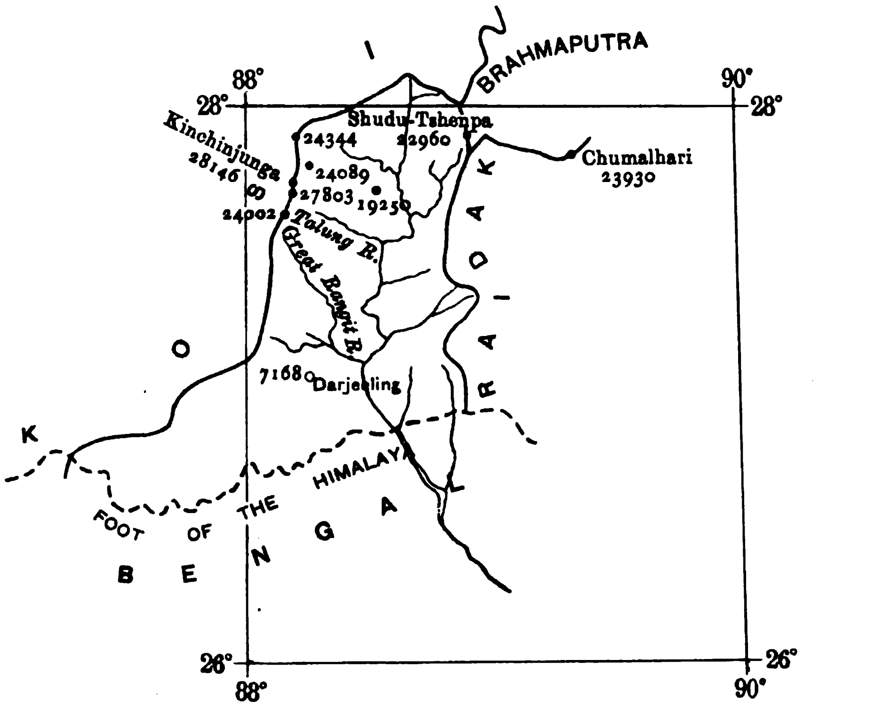
BÁGHMATI

CHART XXVIII



HIMALAYAN AREA DRAINED BY THE

KOSI



HIMALAYAN AREA DRAINED BY THE

TISTA

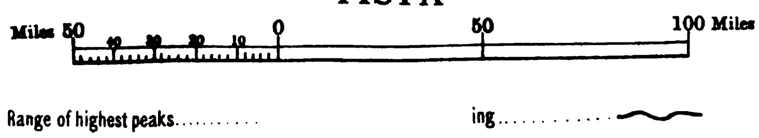
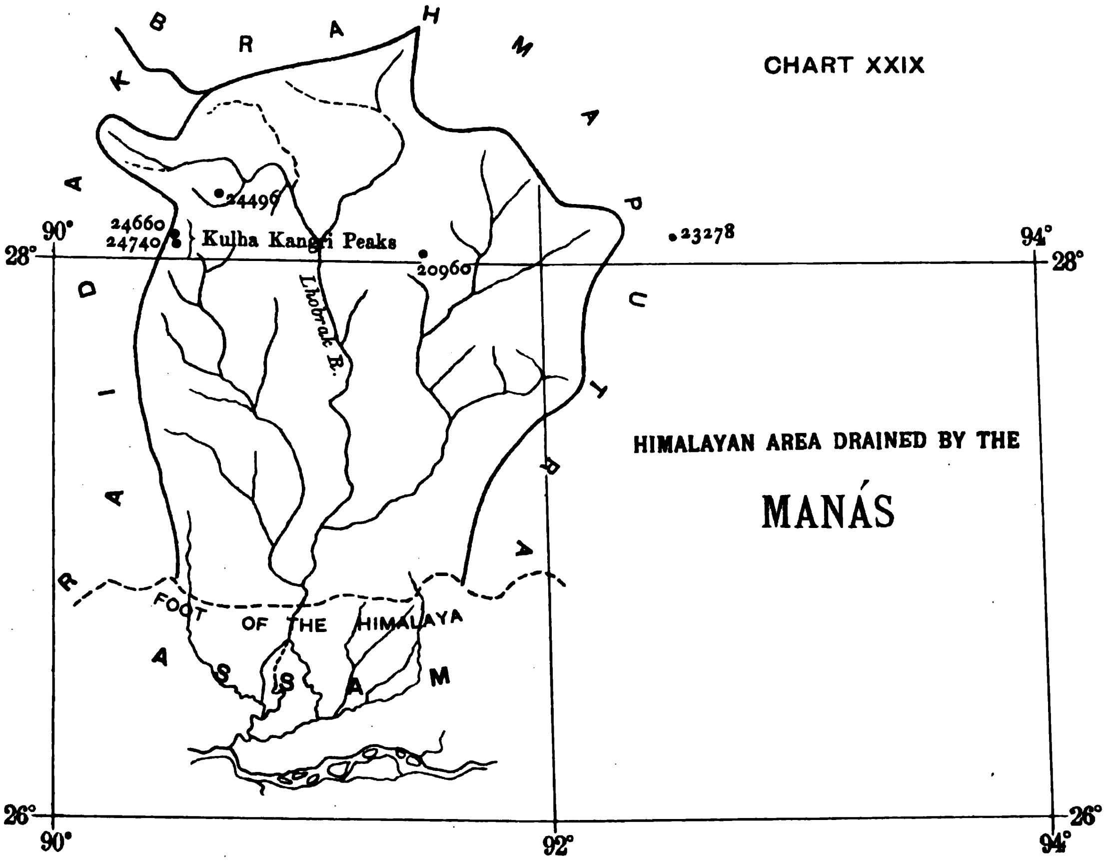
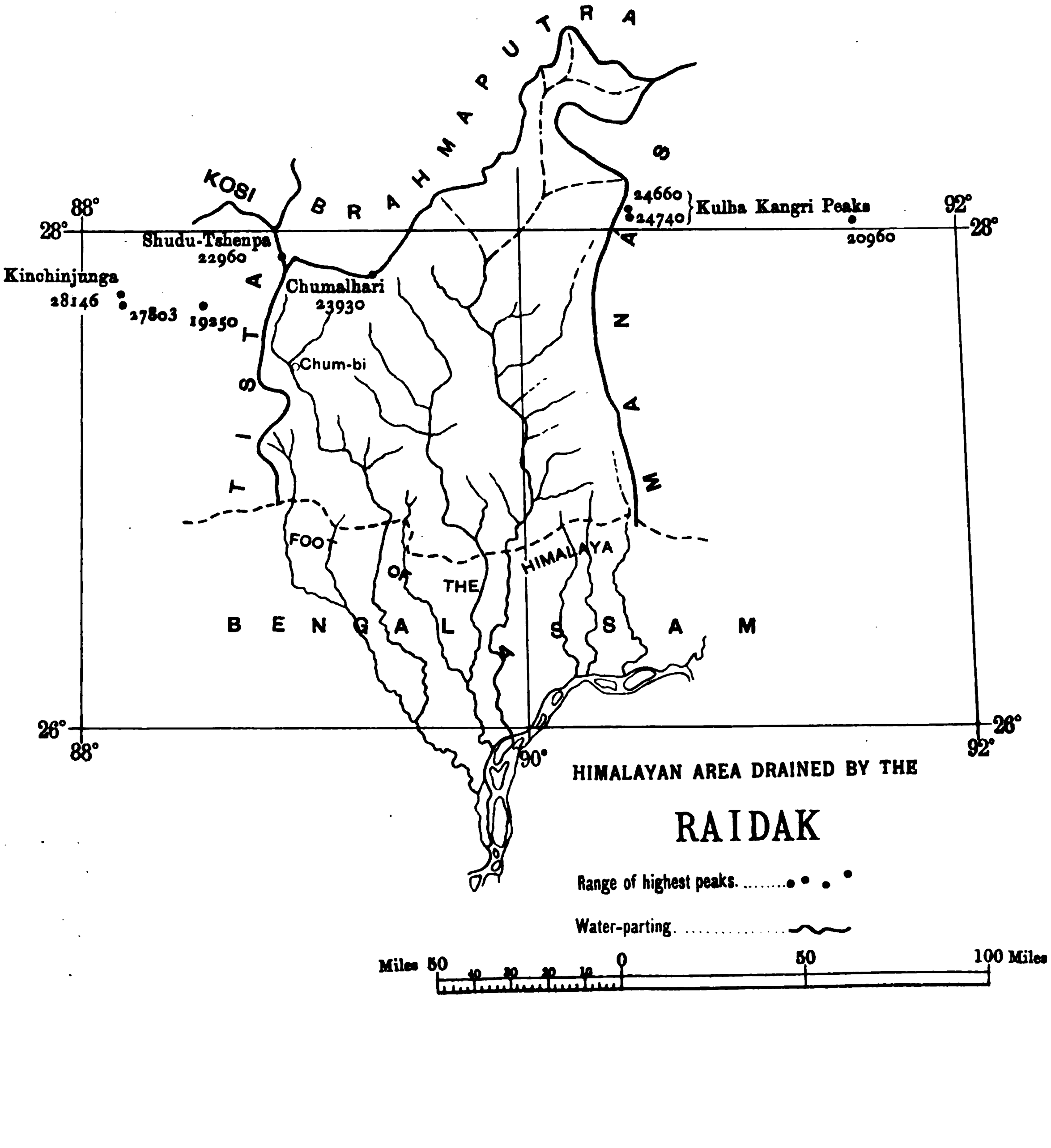


CHART XXIX



HIMALAYAN AREA DRAINED BY THE

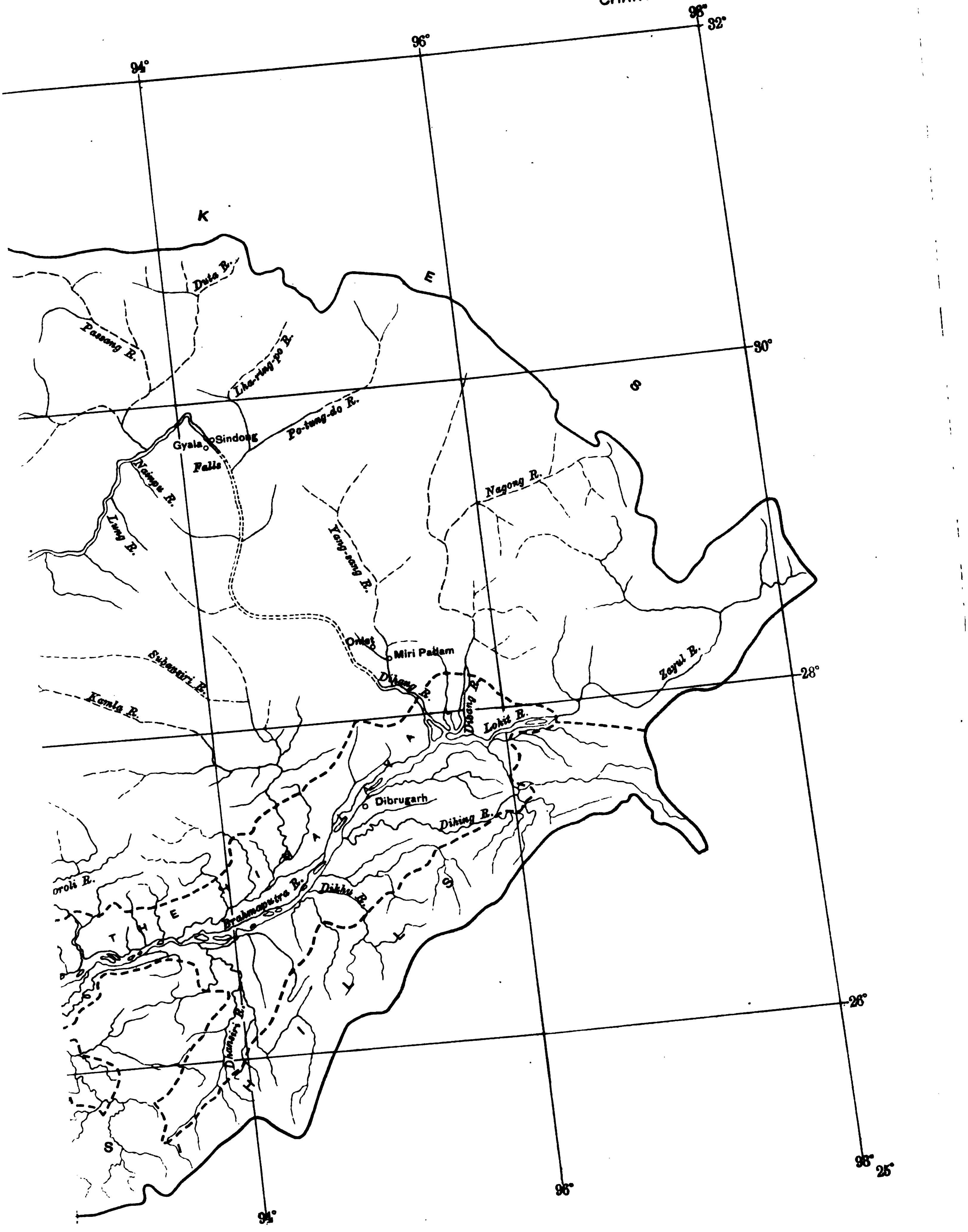
MANÁS



HIMALAYAN AREA DRAINED BY THE

RAIDAK

CHART XXX



98°
32°
96°
94°
30°
28°
26°
25°
K
E
S
Dute R.
Passong R.
Lha-ring-po R.
Po-tung-do R.
Gyala
Sindong
Falls
Naimgu R.
Lung R.
Nagong R.
Yang-sang R.
Onlet
Miri Padam
Subansiri R.
Kamla R.
Dihang R.
Dibang R.
Lohit R.
Zayul R.
Dibrugarh
Diking R.
Dikhu R.
Brahmaputra R.
Dhansiri R.

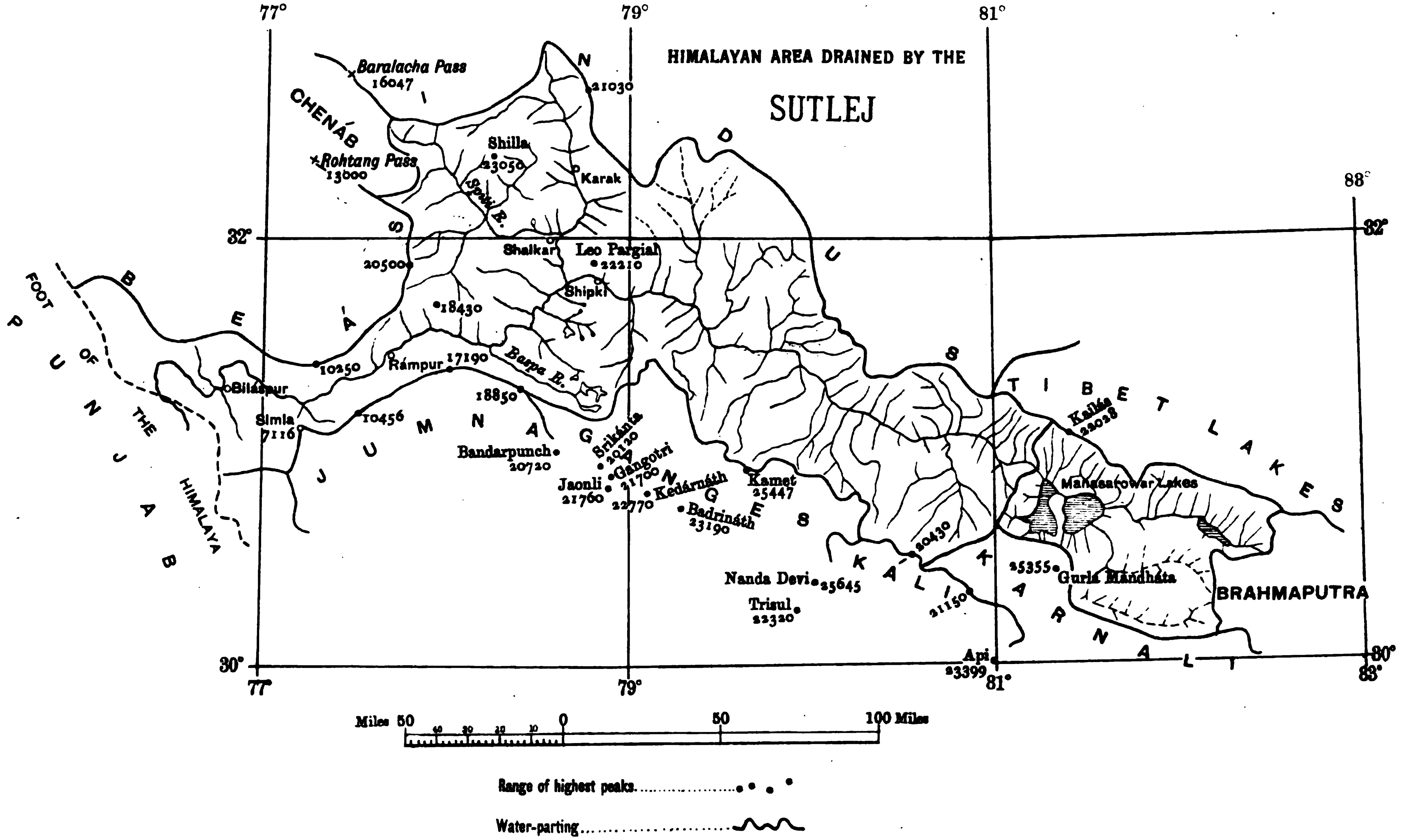
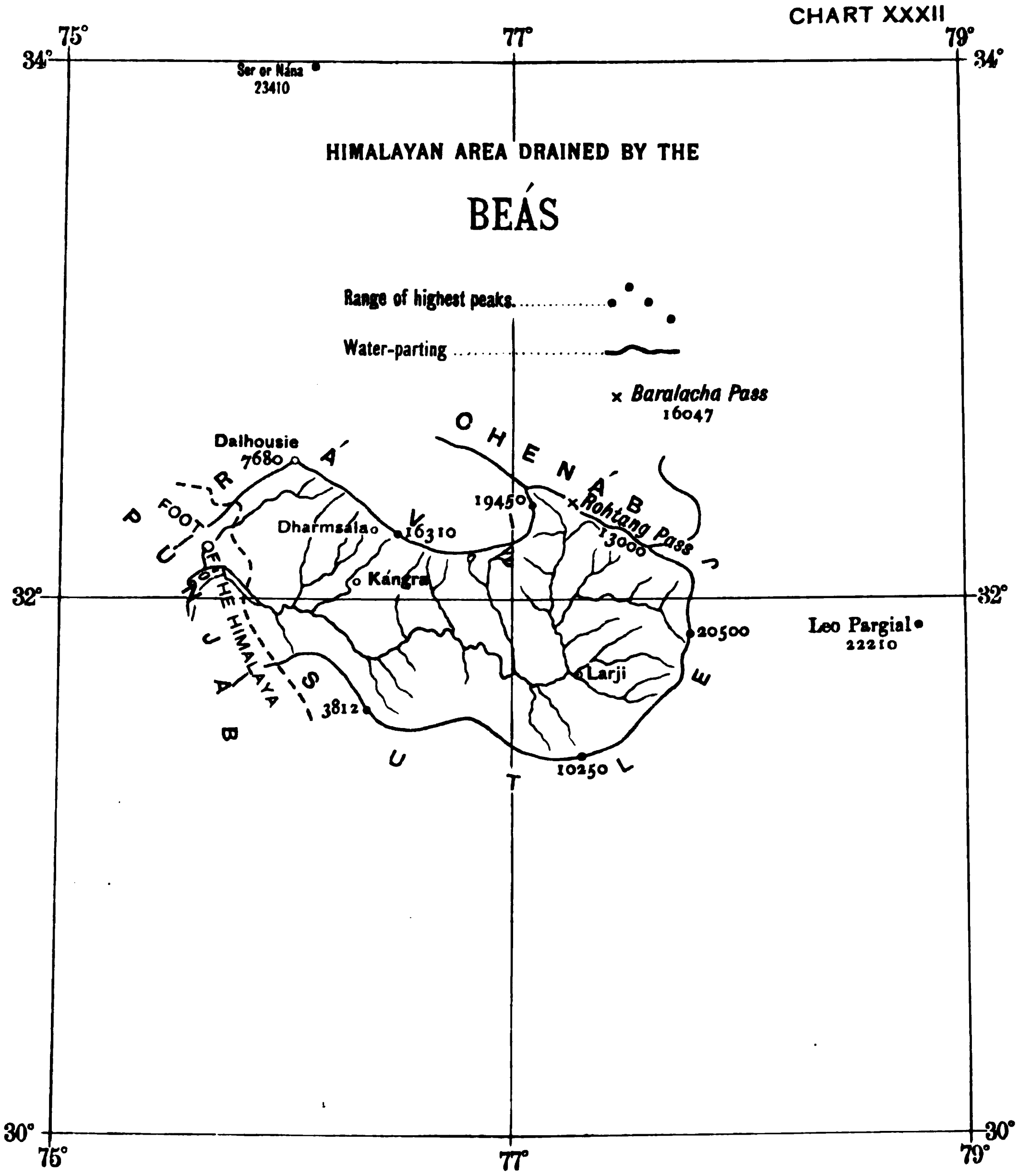
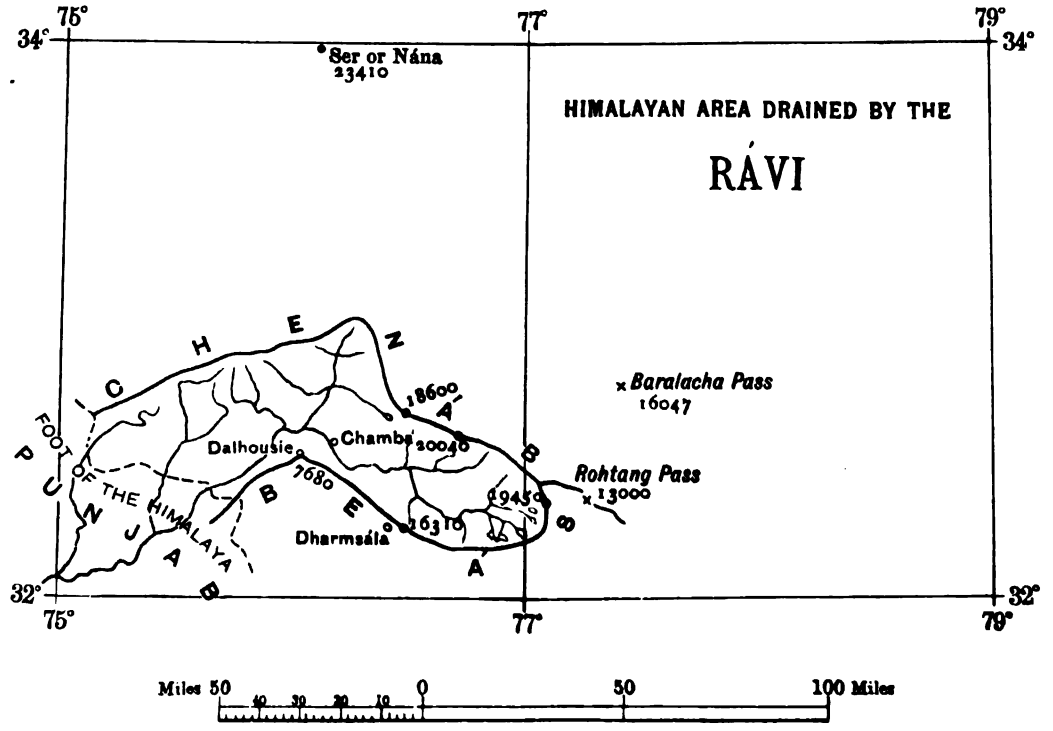

HIMALAYAN AREA DRAINED BY THE
SUTLEJ
77°
79°
81°
88°
32°
30°
83°
Baralacha Pass
16047
CHENÁB
Rohtang Pass
13000
Shilla
23050
Spiti R.
Karak
21030
Shalkar
Leo Pargial
22210
Shipki
20500
18430
Rámpur
17190
10250
Baspa R.
18850
Bilaspur
Simla
7116
10456
Bandarpunch
20720
Srikánta
20120
Gangotri
21700
Jaonli
21760
22770
Kedárnáth
Badrináth
23190
Kamet
25447
Nanda Devi
25645
Trisul
23320
20430
21150
Api
23399
Kailás
22028
Manasarowar Lakes
25355
Gurla Mándháta
BRAHMAPUTRA
FOOT OF THE HIMALAYA
P U N J A B
B E Á S
J U M N A
G A N G E S
K A L I
K A R N A L I
I N D U S
T I B E T L A K E S
Miles 50
40
30
20
10
0
50
100 Miles
Range of highest peaks
Water-parting

CHART XXXII



HIMALAYAN AREA DRAINED BY THE
BEÁS
Range of highest peaks
Water-parting
75°
77°
79°
34°
32°
30°
Ser or Nána 23410
× Baralacha Pass 16047
Dalhousie 7680
Dharmsála
16310
Kángra
19450
Rohtang Pass 13000
20500
Leo Pargial 22210
Larji
3812
10250
FOOT OF THE HIMALAYA
PUNJAB
RÁVI
CHENÁB
SUTLEJ



HIMALAYAN AREA DRAINED BY THE
RÁVI
75°
77°
79°
34°
32°
Ser or Nána 23410
× Baralacha Pass 16047
18600
Chamba
20040
Dalhousie
7680
Rohtang Pass × 13000
19450
16310
Dharmsála
FOOT OF THE HIMALAYA
PUNJAB
CHENÁB
BEÁS
Miles 50 40 30 20 10 0 50 100 Miles

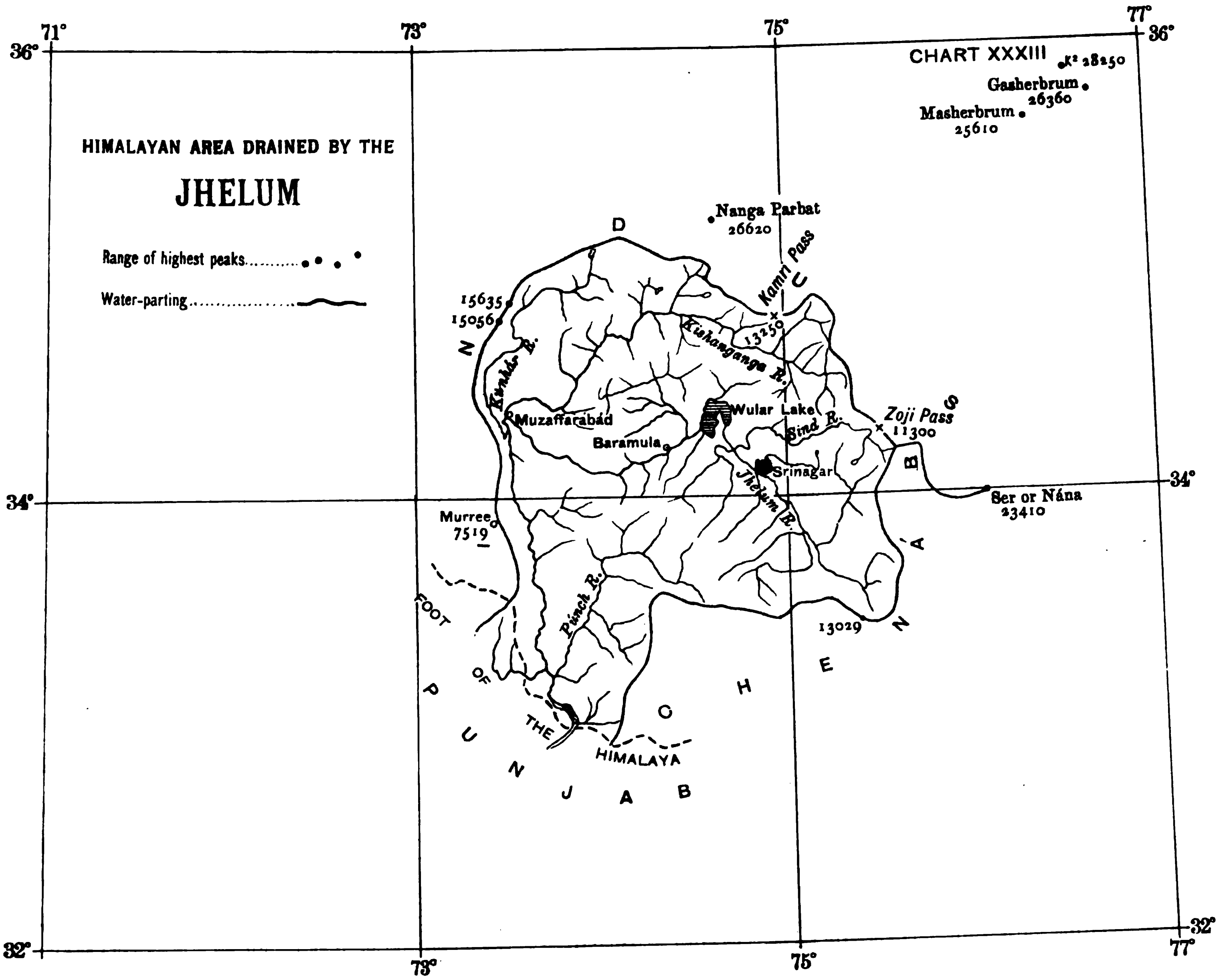
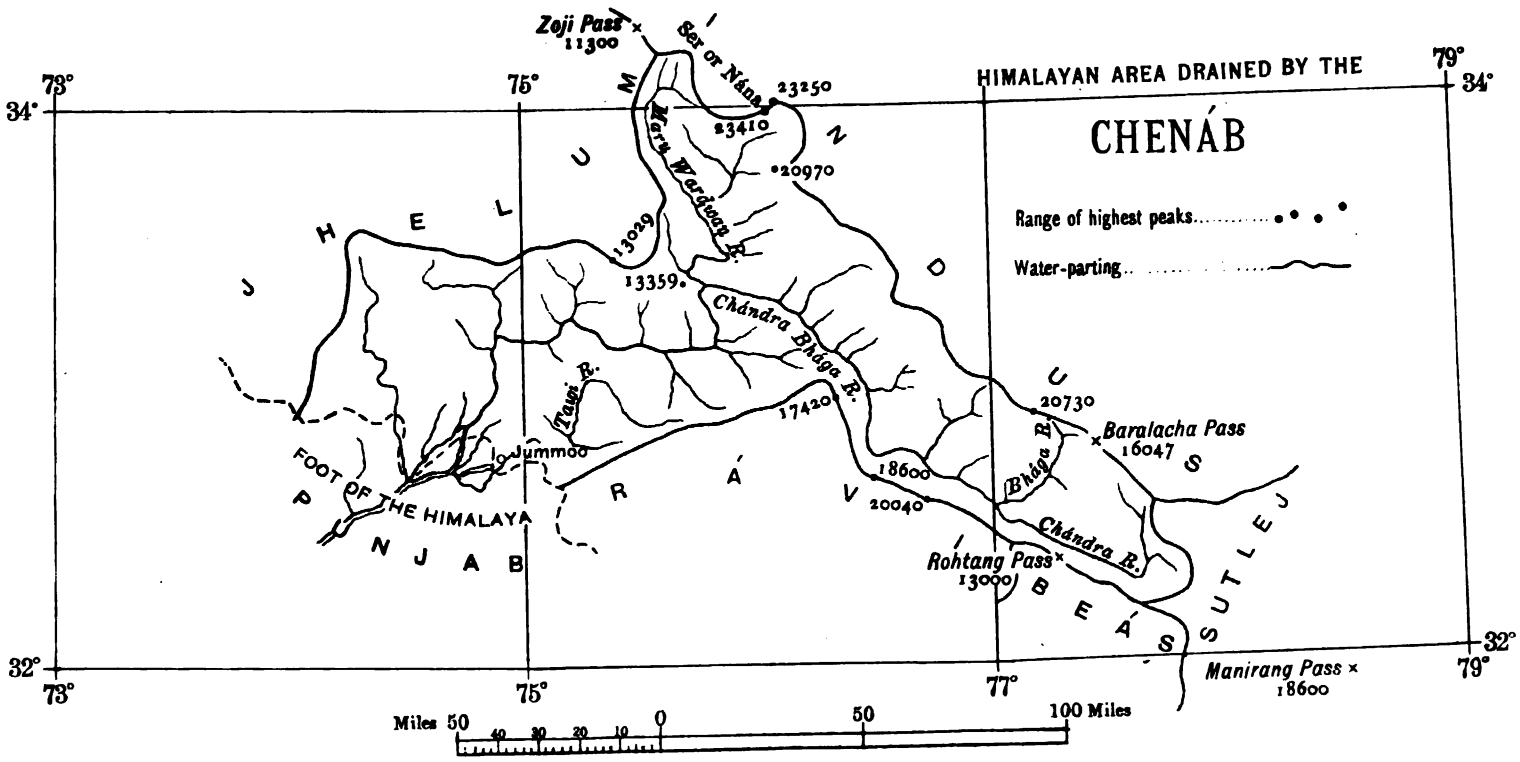
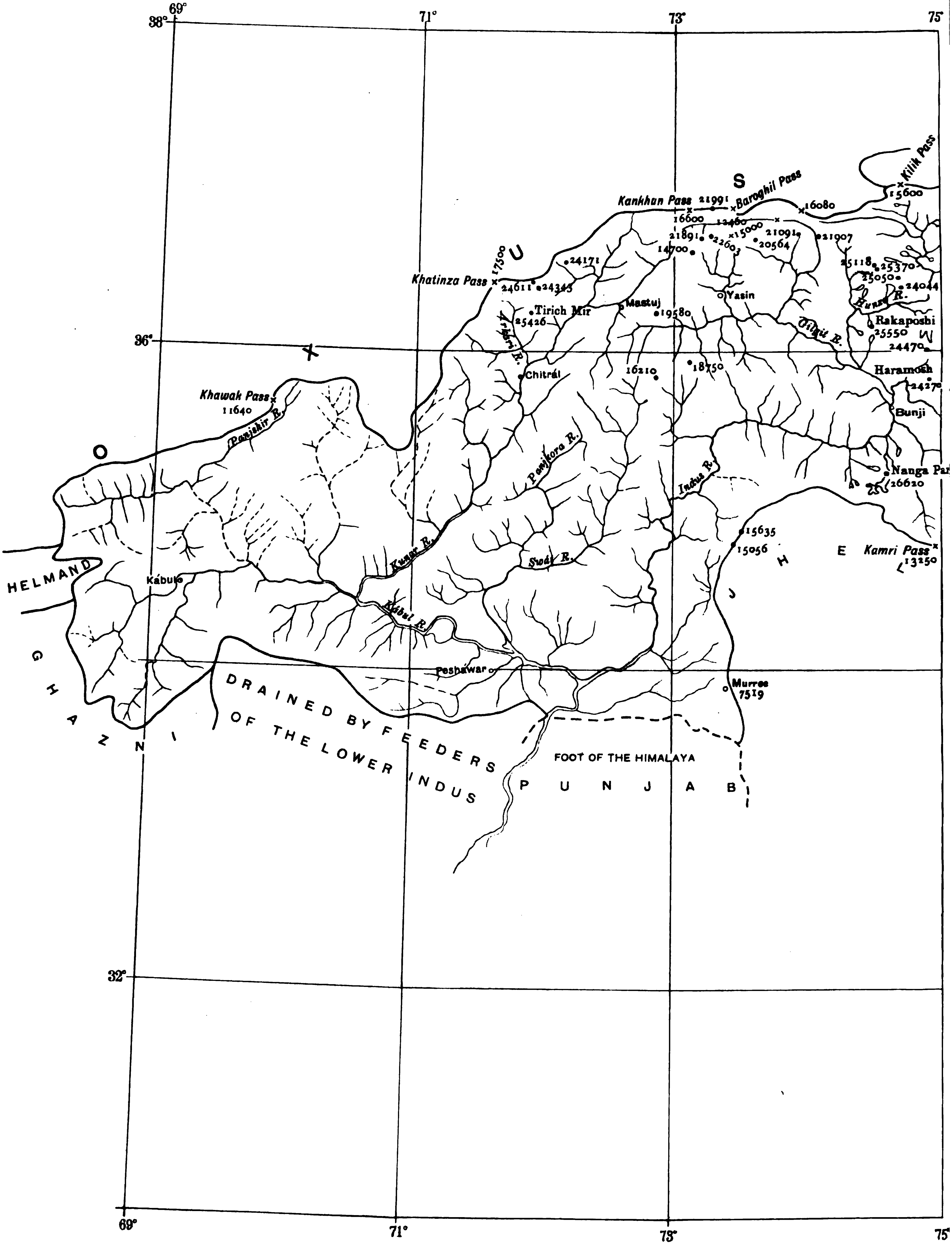


CHART XXXIII
HIMALAYAN AREA DRAINED BY THE
JHELUM
Range of highest peaks
Water-parting
K² 28250
Gasherbrum 26360
Masherbrum 25610
Nanga Parbat 26620
Kamri Pass
13250
Kishanganga R.
Kunhar R.
15635
15056
Muzaffarabad
Wular Lake
Baramula
Sind R.
Zoji Pass 11300
Srinagar
Jhelum R.
Ser or Nána 23410
Murree 7519
Punch R.
13029
FOOT OF THE HIMALAYA
PUNJAB
INDUS
CHENAB


HIMALAYAN AREA DRAINED BY THE
CHENÁB
Range of highest peaks
Water-parting
Zoji Pass 11300
Ser or Nána
23250
23410
20970
Maru Warduan R.
13029
13359
Chándra Bhága R.
Tawi R.
Jummoo
17420
20730
Baralacha Pass 16047
Bhága R.
18600
20040
Chándra R.
Rohtang Pass 13000
Manirang Pass 18600
FOOT OF THE HIMALAYA
PUNJAB
JHELUM
INDUS
RÁVI
BEÁS
SUTLEJ
Miles 50 40 30 20 10 0 50 100 Miles



69°
71°
73°
75°
38°
36°
32°
O
X
U
S
Kankhan Pass
Baroghil Pass
Kilik Pass
Khatinza Pass
Khawak Pass
Kamri Pass
Tirich Mir
Mastuj
Yasin
Chitral
Rakaposhi
Haramosh
Bunji
Nanga Par
Murree
Peshawar
Kabul
Panjshir R.
Kunar R.
Kabul R.
Panjkora R.
Swat R.
Indus R.
Gilgit R.
Hunza R.
HELMAND
GHAZNI
DRAINED BY FEEDERS OF THE LOWER INDUS
FOOT OF THE HIMALAYA
PUNJAB
HIMALAYA

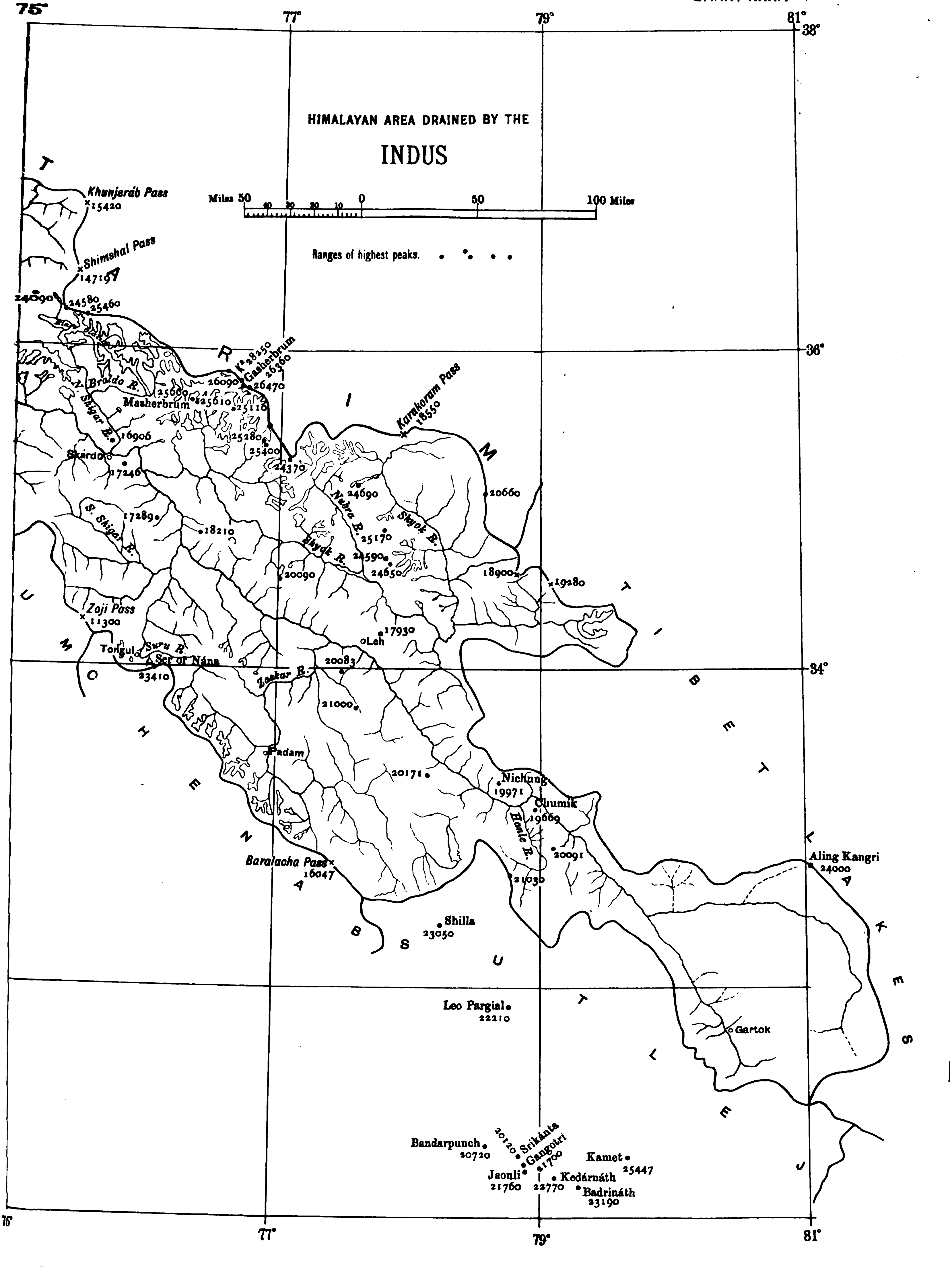

HIMALAYAN AREA DRAINED BY THE
INDUS
Miles 50 40 30 20 10 0 50 100 Miles
Ranges of highest peaks.
75°
77°
79°
81°
38°
36°
34°
Khunjerab Pass
15420
Shimshal Pass
14719
24580
25460
K2 28250
Gasherbrum
26360
26470
26090
Braldo R.
N. Shigar R.
Masherbrum
25660
25610
25110
25280
25400
24370
Karakoram Pass
18550
16906
Skardo
17246
17289
S. Shigar R.
18210
24690
Nubra R.
Shyok R.
25170
24590
24650
20660
20090
18900
19280
Zoji Pass
11300
Tongul
Suru R.
Ser or Nána
23410
Leh
17930
20083
Zaskar R.
21000
Padam
20171
Nichung
19971
Chumik
19669
Hanle R.
20091
21030
Baralacha Pass
16047
Shilla
23050
Aling Kangri
24000
Gartok
Leo Pargial
22210
Bandarpunch
20720
20120
Srikánta
Gangotri
21700
Jaonli
21760
22770
Kedárnáth
Kamet
25447
Badrináth
23190
T R I M
T I B E T
U M C H E N
A B S U T L E J
L A K E S

CHART XXXV

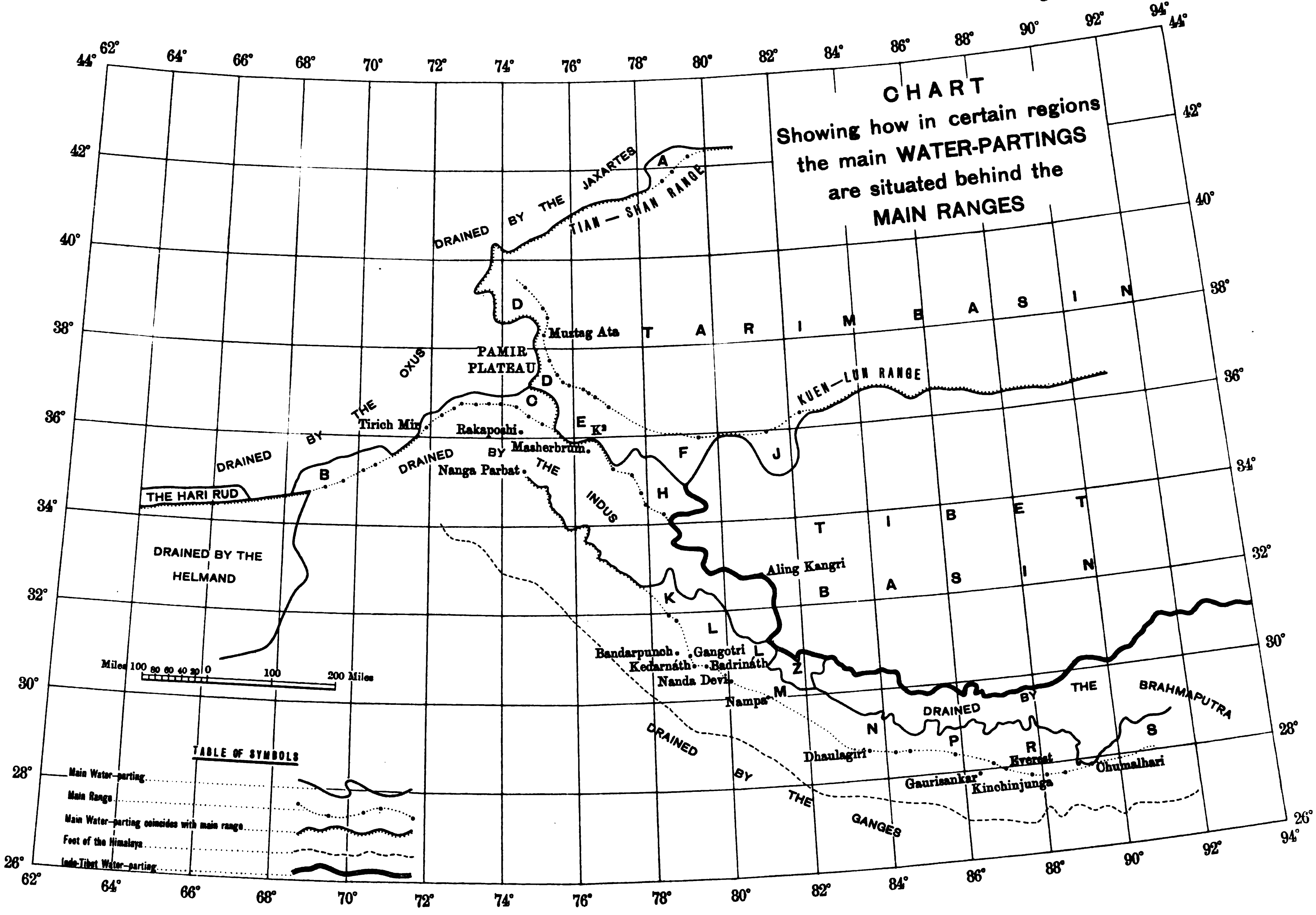


CHART
Showing how in certain regions the main WATER-PARTINGS are situated behind the MAIN RANGES
DRAINED BY THE JAXARTES
TIAN — SHAN RANGE
TARIM BASIN
KUEN—LUN RANGE
Mustag Ata
PAMIR PLATEAU
DRAINED BY THE OXUS
Tirich Mir
Rakaposhi
K²
Masherbrum
Nanga Parbat
DRAINED BY THE INDUS
THE HARI RUD
DRAINED BY THE HELMAND
TIBET BASIN
Aling Kangri
Bandarpunch
Gangotri
Kedarnáth
Badrináth
Nanda Devi
Nampa
Dhaulagiri
Everest
Gaurisankar
Kinchinjunga
Chumalhari
DRAINED BY THE BRAHMAPUTRA
DRAINED BY THE GANGES
A
B
C
D
D
E
F
H
J
K
L
L
M
N
P
R
S
Z
Miles 100 80 60 40 20 0 100 200 Miles
TABLE OF SYMBOLS
Main Water-parting
Main Range
Main Water-parting coincides with main range
Foot of the Himalaya
Indo-Tibet Water-parting

CHART XXXVI

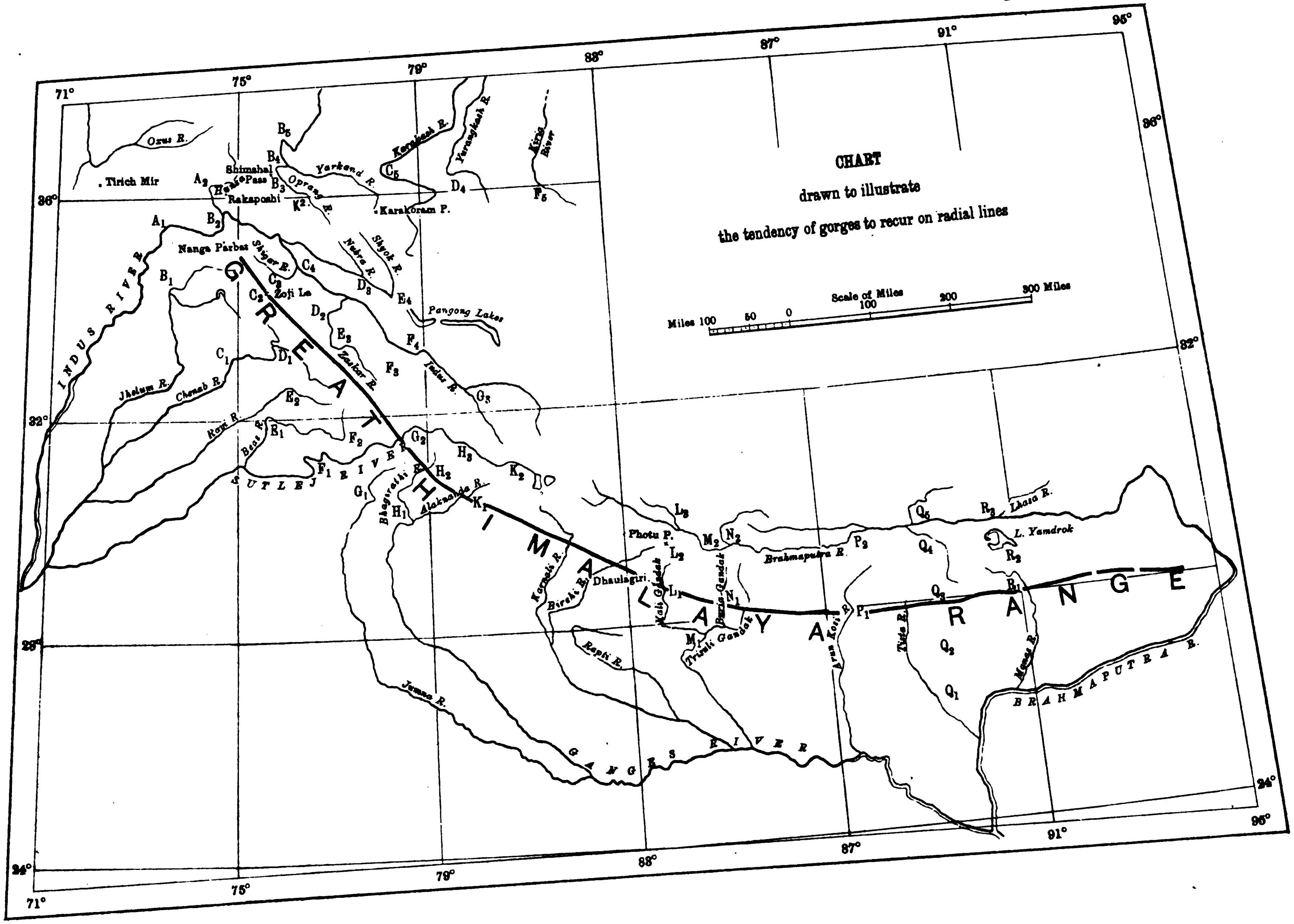


CHART
drawn to illustrate
the tendency of gorges to recur on radial lines
Scale of Miles
Miles 100 50 0 100 200 300 Miles
GREAT HIMALAYA RANGE
INDUS RIVER
SUTLEJ RIVER
GANGES RIVER
BRAHMAPUTRA R.
Oxus R.
Tirich Mir
Nanga Parbat
Rakaposhi
Shimshal
Yarkand R.
Karakash R.
Yarungkash R.
Kiria River
Karakoram P.
Shyok R.
Nubra R.
Shigar R.
Zoji La
Pangong Lakes
Zaskar R.
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Beas R.
Bhagirathi R.
Alaknanda R.
Jumna R.
Karnali R.
Bheri R.
Rapti R.
Dhaulagiri
Kali Gandak
Buria Gandak
Trisuli Gandak
Photu P.
Brahmaputra R.
Arun Kosi R.
Tista R.
Manas R.
L. Yamdrok
Lhasa R.

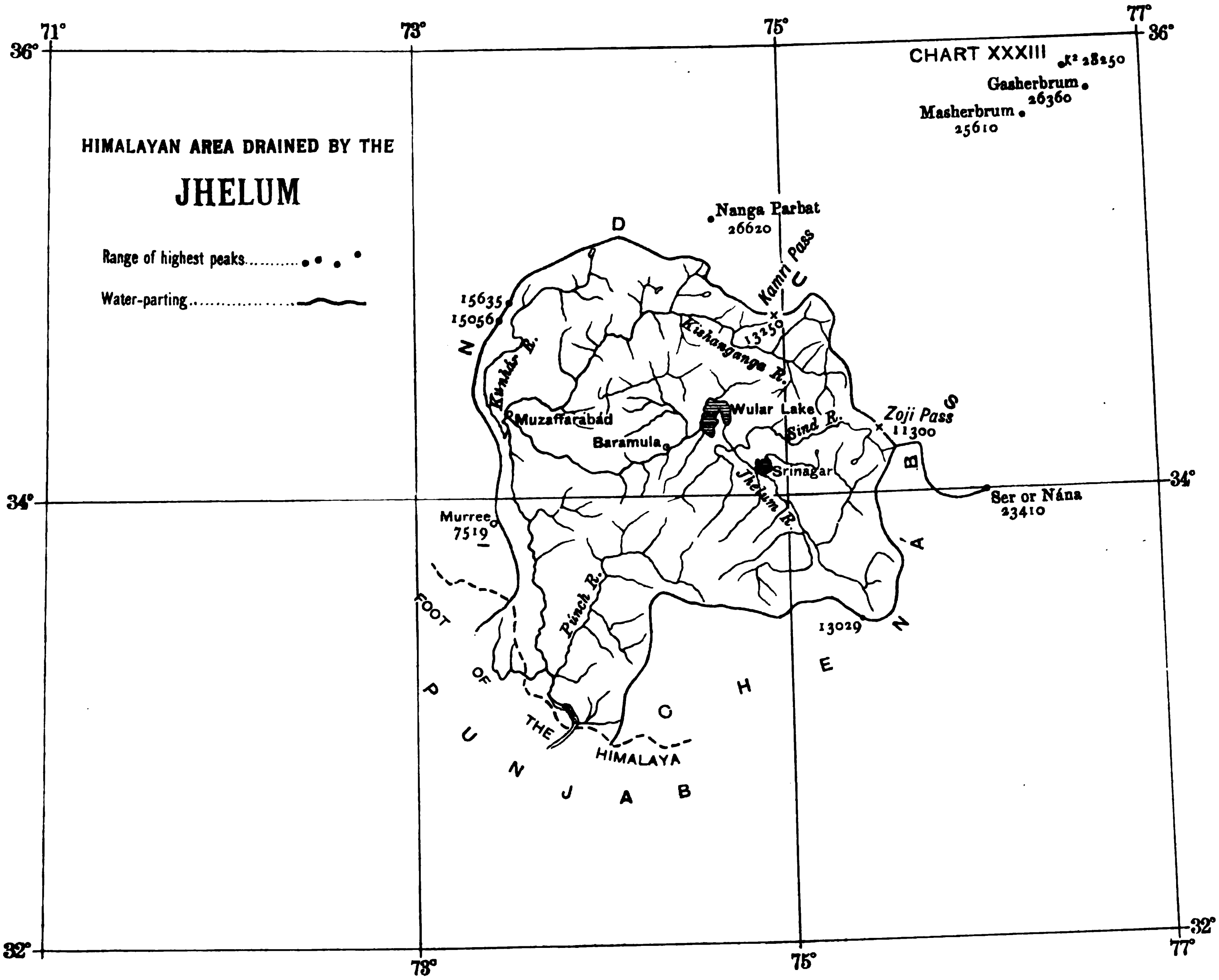
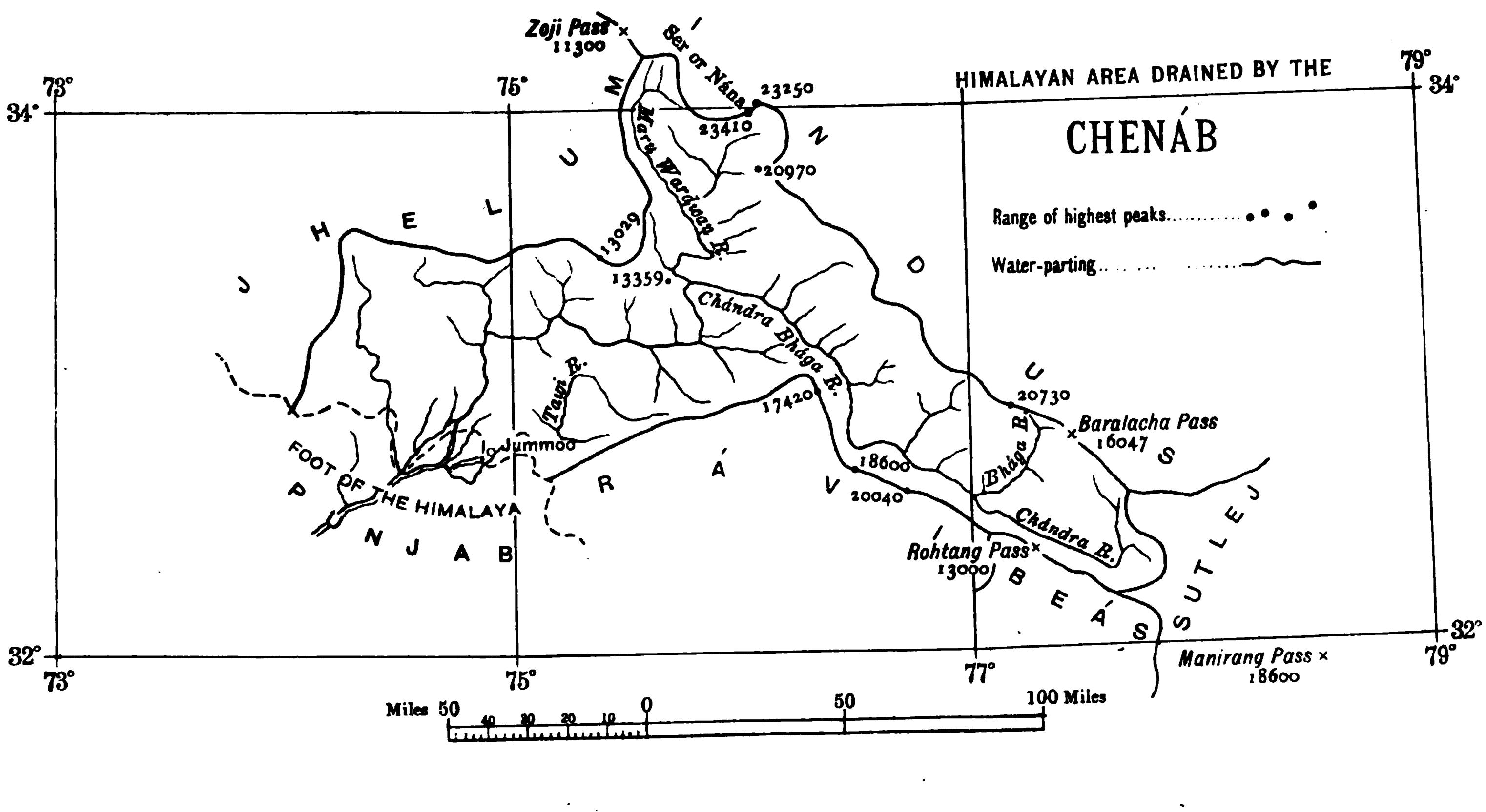
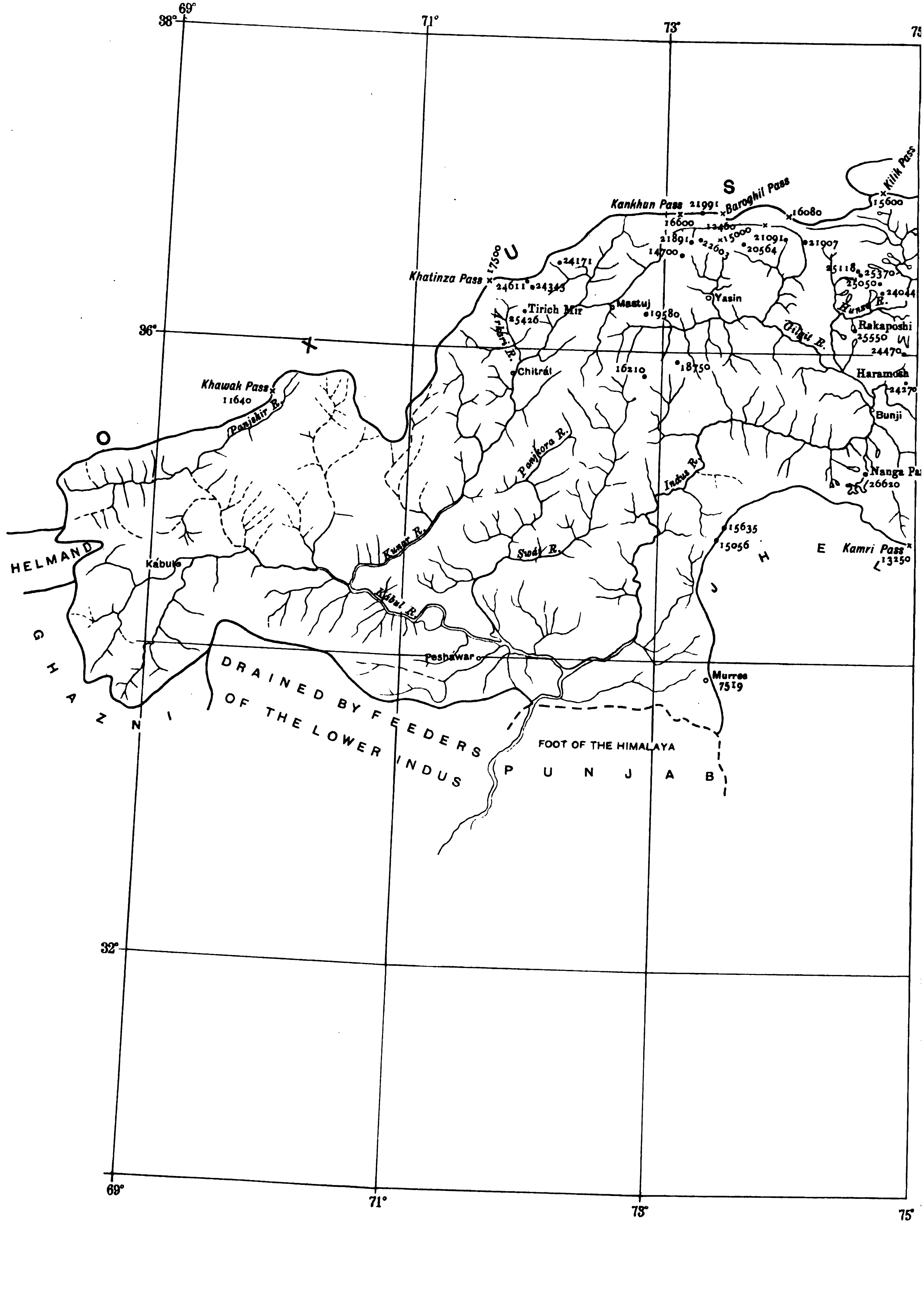


CHART XXXIII
HIMALAYAN AREA DRAINED BY THE
JHELUM
Range of highest peaks
Water-parting
K² 28250
Gasherbrum
26360
Masherbrum
25610
Nanga Parbat
26620
Kamri Pass
13250
Kishanganga R.
15635
15056
Kunhār R.
Muzaffarabad
Baramula
Wular Lake
Sind R.
Zoji Pass
11300
Srinagar
Jhelum R.
Ser or Nána
23410
Murree
7519
Púnch R.
13029
FOOT OF THE HIMALAYA
PUNJAB
CHENAB
INDUS
71°
73°
75°
77°
36°
34°
32°


HIMALAYAN AREA DRAINED BY THE
CHENÁB
Range of highest peaks
Water-parting
Zoji Pass
11300
Ser or Nána
23250
23410
20970
Maru Wardwan R.
13029
13359
Chándra Bhága R.
Tawi R.
Jummoo
17420
18600
20040
20730
Baralacha Pass
16047
Bhága R.
Chándra R.
Rohtang Pass
13000
Manirang Pass
18600
JHELUM
INDUS
RÁVI
BEÁS
SUTLEJ
FOOT OF THE HIMALAYA
PUNJAB
Miles 50
40
30
20
10
0
50
100 Miles
73°
75°
77°
79°
34°
32°



69°
71°
73°
38°
36°
32°
OXUS
Kankhun Pass
21991
Baroghil Pass
16600
16080
Kilik Pass
15600
Khatinza Pass
17500
24611
24343
24171
Tirich Mir
25426
Mastuj
19580
Yasin
21907
Hunza R.
Rakaposhi
25550
24470
Gilgit R.
Chitral
16210
18750
Haramosh
Bunji
26620
Khawak Pass
11640
Panjshir R.
Panjkora R.
Kunar R.
Swat R.
Kabul R.
Indus R.
HELMAND
Kabul
Peshawar
Murree
7519
15635
15056
Kamri Pass
13250
GHAZNI
DRAINED BY FEEDERS OF THE LOWER INDUS
FOOT OF THE HIMALAYA
PUNJAB

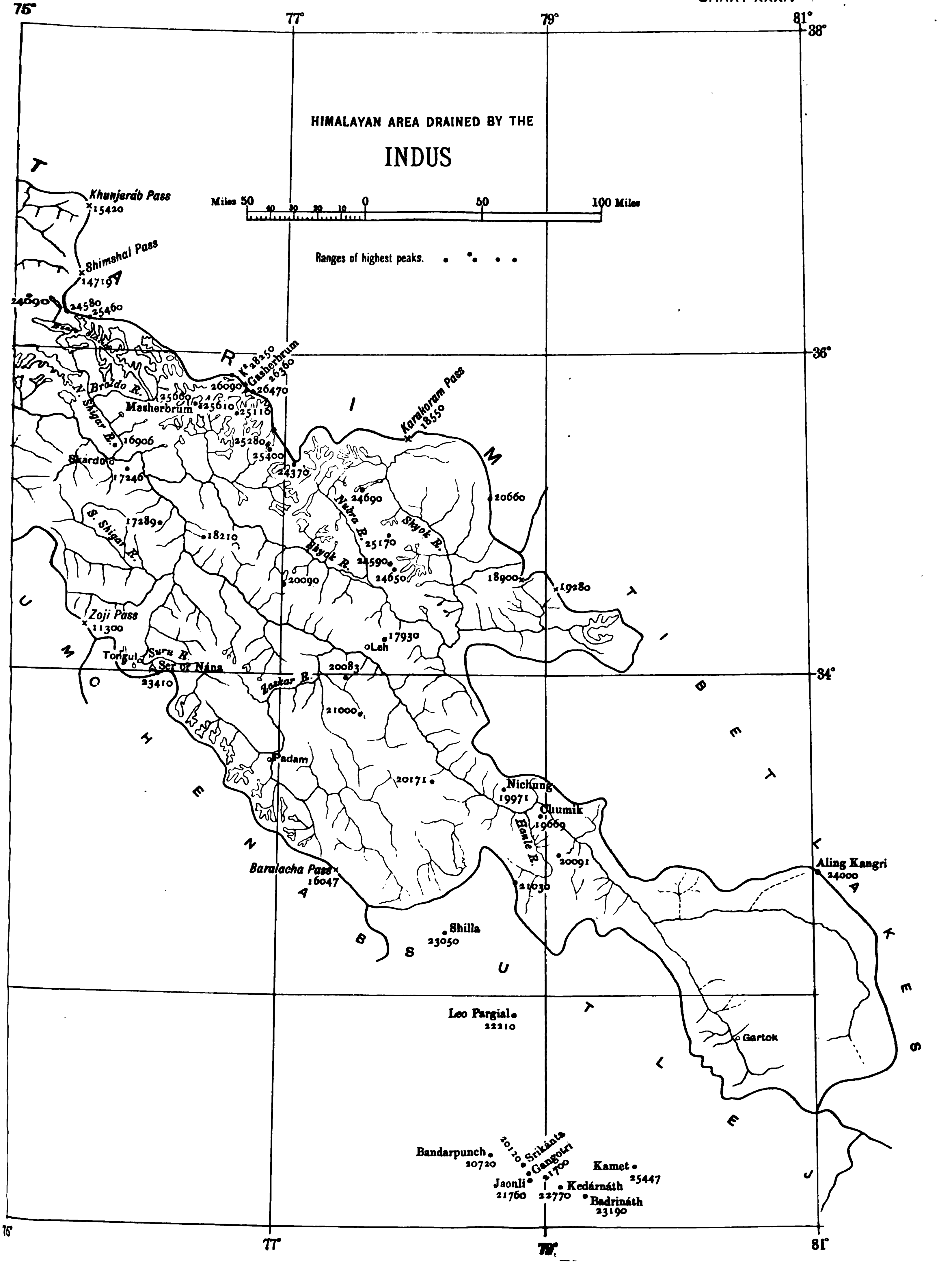

HIMALAYAN AREA DRAINED BY THE
INDUS
Miles 50 40 30 20 10 0 50 100 Miles
Ranges of highest peaks.
75°
77°
79°
81°
38°
36°
34°
Khunjerab Pass
15420
Shimshal Pass
14719
24090
24580
25460
K² 28250
Gasherbrum
26360
26090
26470
Karakoram Pass
18550
Braldo R.
N. Shigar R.
25660
25610
25110
Masherbrum
16906
25280
25400
Skardo
17246
24370
24690
20660
S. Shigar R.
17289
18210
Nubra R.
Shyok R.
25170
24590
24650
20090
18900
19280
Zoji Pass
11300
17930
Leh
Tongul
Suru R.
Ser or Nána
23410
20083
Zaskar R.
21000
Padam
20171
Nichung
19971
Chumik
19669
Hanle R.
20091
Baralacha Pass
16047
21030
Shilla
23050
Aling Kangri
24000
Leo Pargial
22210
Gartok
Bandarpunch
20720
20120
Srikánta
Gangotri
21700
Kamet
25447
Jaonli
21760
22770
Kedárnáth
Badrináth
23190
TRIMI
TIBET
LAKES
UMCHENAB
SUTLEJ
75°
77°
79°
81°

CHART XXXV

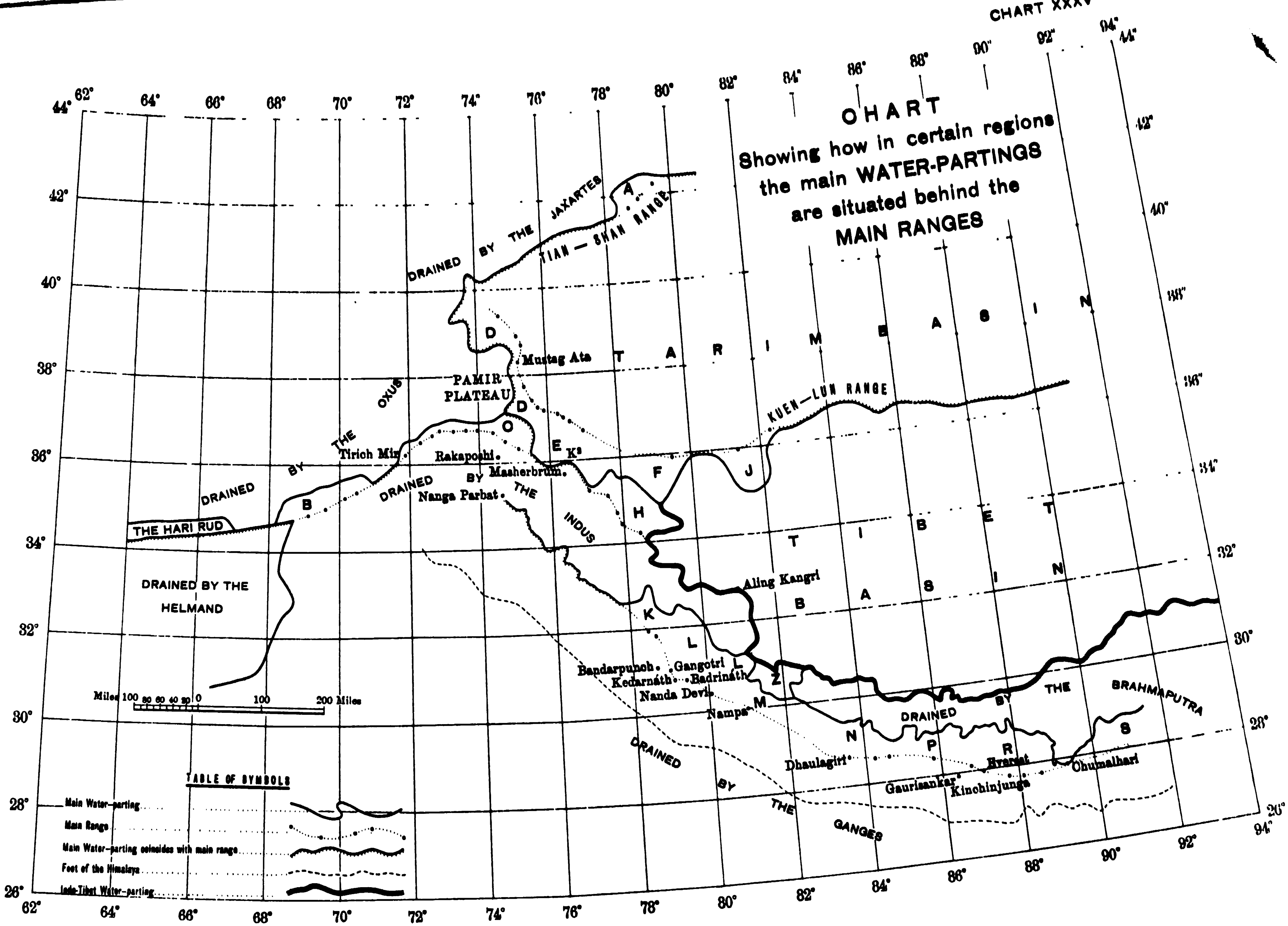


CHART
Showing how in certain regions the main WATER-PARTINGS are situated behind the MAIN RANGES
DRAINED BY THE JAXARTES
TIAN—SHAN RANGE
TARIM BASIN
KUEN—LUN RANGE
TIBET BASIN
Mustag Ata
PAMIR PLATEAU
OXUS
DRAINED BY THE
THE HARI RUD
DRAINED BY THE HELMAND
Tirich Mir
Rakaposhi
Masherbrum
Nanga Parbat
DRAINED BY THE INDUS
K²
Aling Kangri
Bandarpunch
Gangotri
Kedarnath
Badrinath
Nanda Devi
Nampa
Dhaulagiri
Gaurisankar
Kinchinjunga
Everest
Chumalhari
DRAINED BY THE BRAHMAPUTRA
DRAINED BY THE GANGES
Miles 100 80 60 40 20 0 100 200 Miles
TABLE OF SYMBOLS
Main Water-parting
Main Range
Main Water-parting coincides with main range
Foot of the Himalaya
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CHART XXXVI

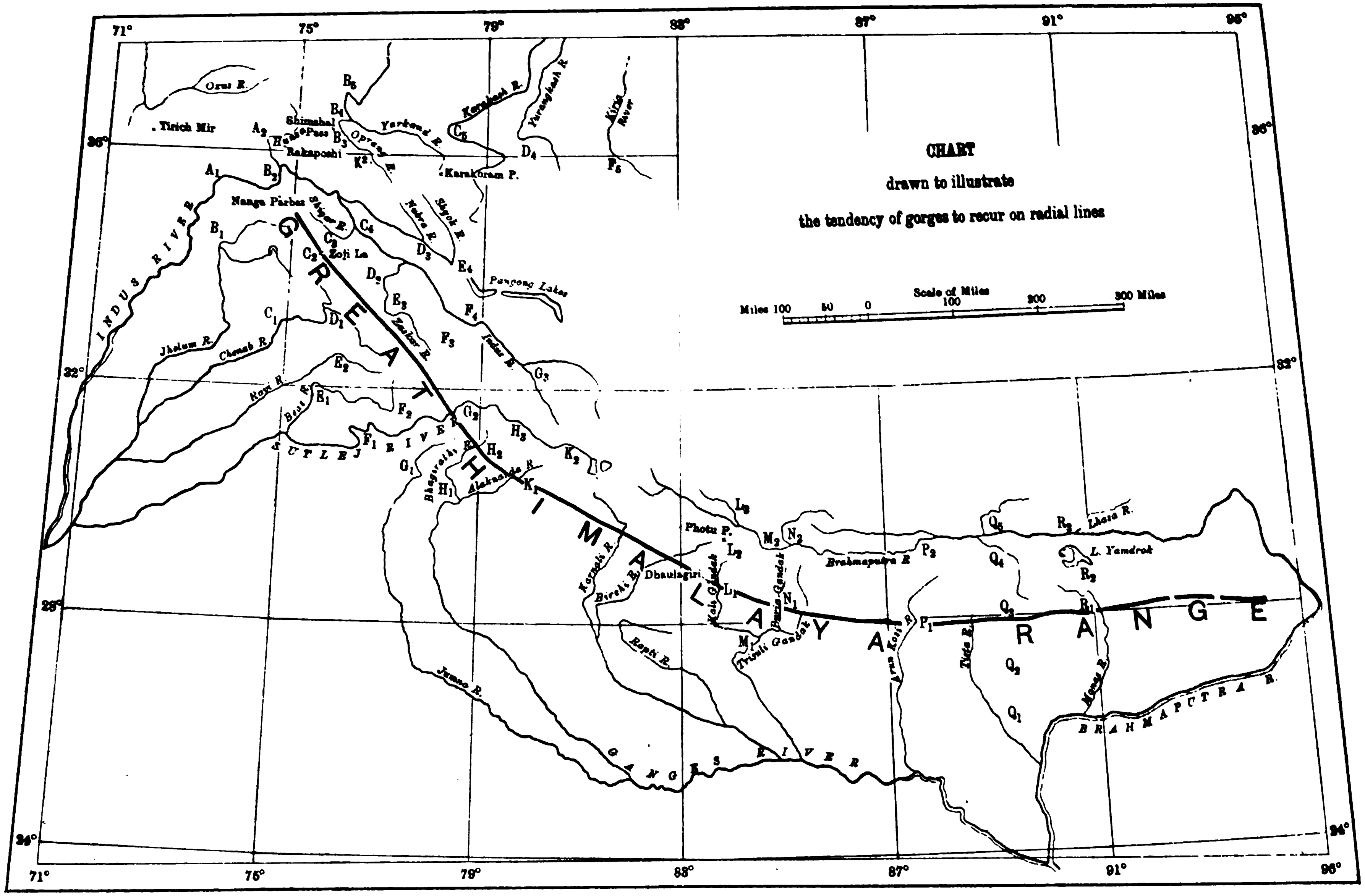
CHART
drawn to illustrate
the tendency of gorges to recur on radial lines
Scale of Miles
Miles 100 50 0 100 200 300 Miles
GREAT HIMALAYA RANGE
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SUTLEJ RIVER
GANGES RIVER
BRAHMAPUTRA R.
Tirich Mir
Oxus R.
Shimshal
Hunza Pass
Rakaposhi
Nanga Parbat
Zoji La
K2
Karakoram P.
Yarkand R.
Oprang R.
Karakash R.
Yurungkash R.
Kirya River
Shigar R.
Nubra R.
Shyok R.
Pangong Lakes
Zaskar R.
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Beas R.
Bhagirathi R.
Alaknanda R.
Jumna R.
Karnali R.
Bheri R.
Rapti R.
Dhaulagiri
Photu P.
Kali Gandak
Buria Gandak
Trisuli Gandak
Brahmaputra R.
Arun Kosi R.
Tista R.
Manas R.
L. Yamdrok
Lhasa R.
71° 75° 79° 83° 87° 91° 95°
36° 32° 28° 24°

CHART XXXVII

CHART
to illustrate the varying gradients of rivers

DIAGRAM 1.
A river rising in the Great Himalaya Range

Examples: Mandakini, Tons, Seti, Indráwati

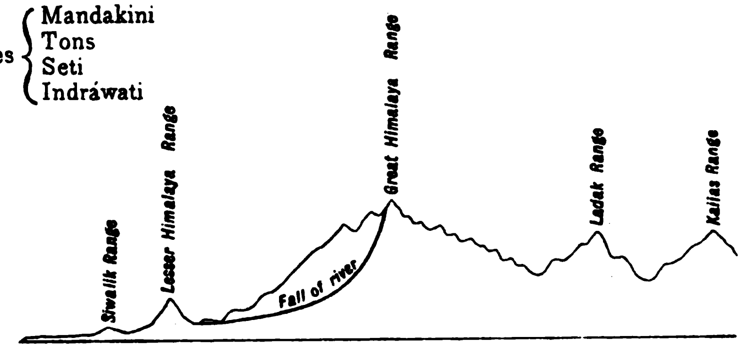


DIAGRAM 2.
A river rising slightly beyond the crest of the Great Range

Examples: Dudh Kosi, Mádi

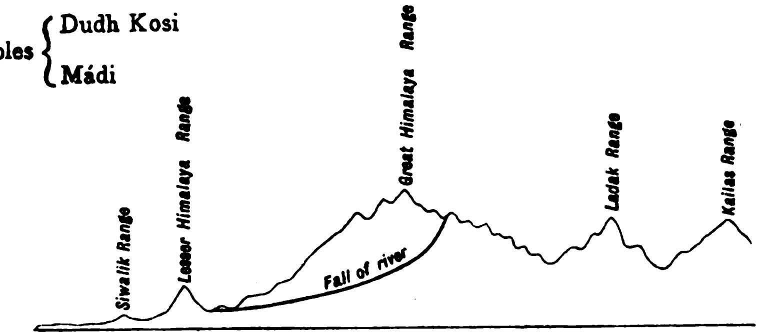


DIAGRAM 3.
A river rising considerably beyond the crest of the Great Range

Examples: Bhotia Kosi, Tambar Kosi

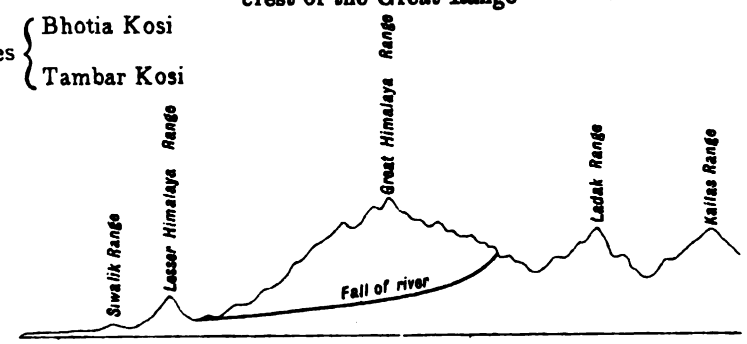


DIAGRAM 4.
A river rising in the trough behind the Great Range

Examples: Arun, Birehi, Bhágirathi, Karnáli

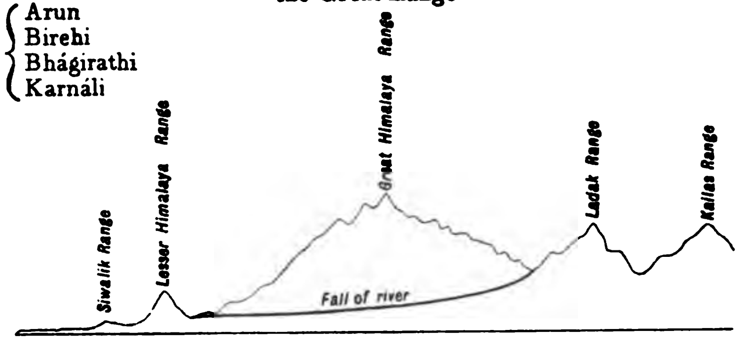


DIAGRAM 5.
A river rising behind the crest of the Ladak Range.

Examples: Káli Gandak, Buria Gandak

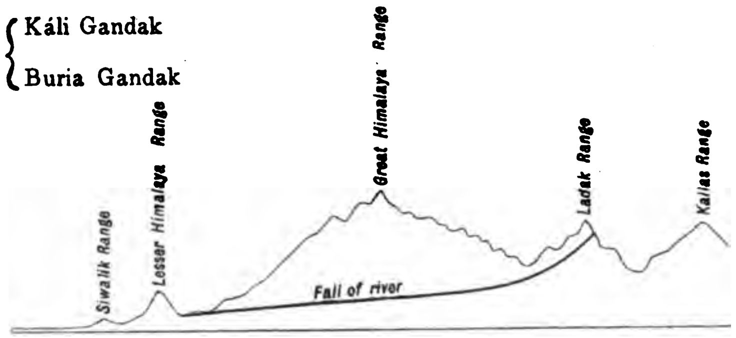
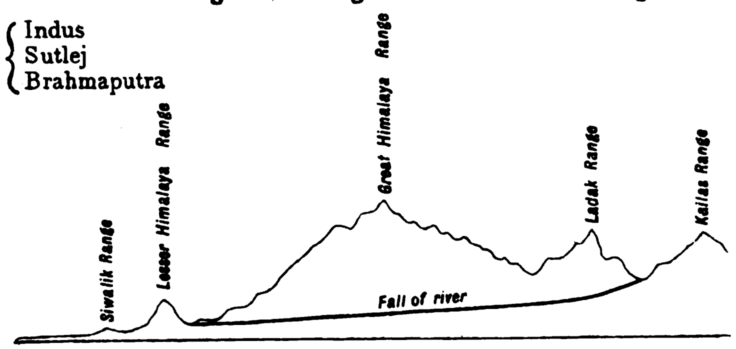


DIAGRAM 6.
A river rising in the trough behind the Ladak Range.

Examples: Indus, Sutlej, Brahmaputra



this book should b